GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. A-3121 DATE 12/8/81

Project Director: Doug Moore School/Lab TAL

Sponsor: Office of Planning & Budget/Georgia Office of Energy Resources; Atlanta, GA

Type Agreement: unnumbered, undated contract under ARC Grant No. GA-6908-81-C1-2000-0331

Award Period: From 10/1/81 To ~~9/30/82~~ 12/31/82 (Performance) ______ (Reports)

Sponsor Amount: $79,784 Contracted through:

Cost Sharing: N/A GTRI/~~GIT~~

Title: Energy Conservation Assistance to Georgia Appalachian Industries

ADMINISTRATIVE DATA OCA Contact Leamon R. Scott

1) Sponsor Technical Contact:

Mark Zwecker, Director
Office of Energy Resources
Office of Planning & Budget
270 Washington St., S.W.
Atlanta, GA 30334

2) Sponsor Admin/Contractual Matters:

Mark Zwecker, Director
Office of Energy Resources
Office of Planning & Budget
270 Washington St., S.W.
Atlanta, GA 30334

Defense Priority Rating: N/A Security Classification: N/A

RESTRICTIONS

See Attached Government Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed

COMMENTS:

COPIES TO:

Administrative Coordinator
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Reports Coordinator (OCA) ✓
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Computer Input
Project File
Other ______

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

N-FEB 87
SR327

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date February 24, 1984

Project No. A-3121

~~School~~/Lab TAL

Includes Subproject No.(s)

Project Director(s) Rick Steenblik GTRI / ~~GIT~~

Sponsor Ga. Office of Energy Resources

Title Energy Conservation Assistance to Georgia Appalachian Industries

Effective Completion Date: 12/31/82 (Performance) 12/31/82 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [x] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
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Project File
Other

Form OCA 60:1028

A-3121

WORK PLAN

FOR A PROGRAM OF ENERGY CONSERVATION ASSISTANCE

TO GEORGIA APPALACHIAN INDUSTRIES

Submitted To:

Georgia Office of Energy Resources

and the Appalachian Regional Commission

ARC Contract No. 81-164

October 12, 1981

Technology Applications Laboratory
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

TABLE OF CONTENTS

I. INTRODUCTION

The purpose of this Work Plan is to define the scope, methodology, and goals of a program of energy conservation assistance to Georgia Appalachian industries. This program, sponsored by the Appalachian Regional Commission and conducted by the Georgia Tech Engineering Experiment Station and the State of Georgia Office of Energy Resources, represents a continuation of the efforts of these organizations under a similar program conducted during 1980. The period of performance of the new program will be from October 1, 1981 to September 30, 1982. The program will continue to be directed toward smaller industries in the Georgia Appalachian Region, specifically those with 200 or less employees.

This program will be conducted in a manner similar to the Industrial Energy Extension Service, a statewide energy conservation program conducted by Georgia Tech and sponsored by the Office of Energy Resources, and will complement that program which heretofore has concentrated on larger industries. The ARC program will provide in-plant energy surveys to at least thirty industrial plants. Emphasis will be on areas requiring little or no capital expenditures. A bi-monthly newsletter addressing energy issues relevant to the region, and other literature necessary to aid the small industries in establishing energy management programs will be developed and distributed. These items are discussed in further detail in the following pages.

II. DEVELOPMENT OF LITERATURE

Energy survey forms, energy consumption forms, and technical information for use by industries in implementing energy conservation techniques have been and will continue to be developed for use in the program. Examples of energy survey and consumption forms proposed for use are included in Appendix A. Technical information covering such areas as electrical demand control systems, lighting, heating and air conditioning, boiler and steam systems, compressed air systems, and operating and maintenance procedures will be developed and made available to area manufacturers through the newsletter mentioned previously and as a part of the energy survey reports.

III. ENERGY SURVEYS

The major effort of the program will be placed on the in-plant energy surveys. The small size of the plants to be surveyed will normally result in a one-day visit, during which the surveyor will discuss with the plant management such topics as current patterns of energy use, monitoring energy costs, and establishing an energy management program. A survey of the facilities will be conducted to identify potential areas for energy conservation. Measurements will be taken to facilitate estimation of the energy and cost savings potential in each area. Instrumentation available for this purpose includes various mechanical and electronic thermometers, volt-amp meters, light level meters, combustion analysis equipment, air velocity measurement equipment and other miscellaneous items. Tests of boiler efficiency will be conducted for all boilers in service.

After completion of the plant visit, a report will be submitted to the plant management outlining specific recommendations for energy conservation identified in their plant. Primary emphasis will be placed on recommendations that require little or no capital expense.

The report will include estimated energy and cost savings, with supporting calculations. Preference will be given to those companies specifically requesting assistance. A minimum of thirty plant surveys will be conducted.

IV. NEWSLETTER

A bi-monthly newsletter will be prepared and distributed to Georgia Appalachian industries. Each edition will contain a case study of the conservation efforts of an area manufacturer. The newsletter may also contain technical information pertinent to the case study, as well as energy related news of interest to the region.

The format of the newsletter will be a one or two page flyer printed on 8 1/2" x 11" stock. Each issue will be distributed to over 1,500 companies in the region, utilizing the computerized mailing list developed by the Technology Applications Laboratory for the previous ARC program. A total of six newsletters will be published. It is felt that a publication of this type will be highly effective in reaching area industries and interesting them in energy conservation projects.

V. REPORTING AND PROGRAM EVALUATION

To determine the effectiveness of the energy assistance program, those firms which receive in-plant assistance will be contacted a sufficient period of time after the survey to determine the degree of implementation of the energy conservation recommendations and actual energy savings. This information will be tabulated and summarized in a final report. A copy of an implementation analysis form developed for this purpose is included in Appendix B.

Quarterly progress reports will be submitted describing program activities for the period and providing such statistics as the number of plants contacted, the number and date of survey reports issued, and the recommended energy savings. A final report will be generated to include:

- Number and kind of contacts made
- Number and kind of energy conservation measures recommended
- Number of recommendations implemented
- Total energy and cost savings recommended
- Actual energy and cost savings
- Percent of population reached
- Evaluation of the program effectiveness

VI. SCHEDULE

The proposed schedule for the project for the 1981-82 project year is shown schematically on the following page. Energy surveys will begin as soon as possible after receipt of approval of this Work Plan.

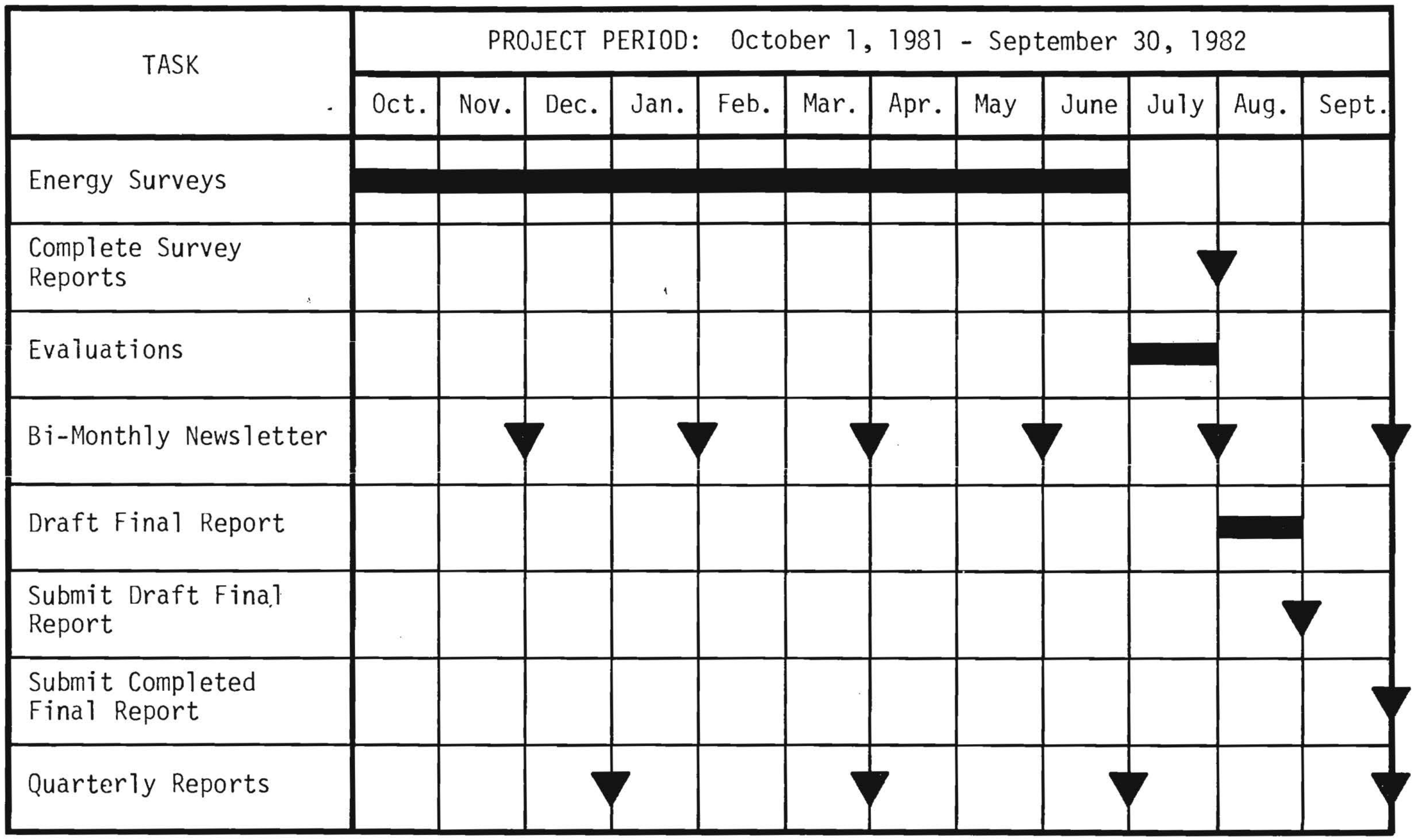


Figure 1 - Program Schedule

Appendix A

Energy Survey Forms

ANNUAL PLANT ENERGY CONSUMPTION

FUEL	ANNUAL CONSUMPTION	CONVERSION FACTOR	EQUIVALENT ENERGY USAGE (MMBTU/YR)	COST ($)	UNIT COST ($/MMBTU)
ELECTRICITY	KWH	.00341			
NATURAL GAS	CU. FT.	0.001			
PROPANE	GAL.	0.090			
L.P. GAS	GAL.	0.095			
NO. 2 OIL	GAL.	0.140			
NO. OIL	GAL.				
NO. 6 OIL	GAL.	0.150			
MISCELLANEOUS					
FUELS					
TOTAL					

ELECTRICAL ENERGY CONSUMPTION

SUPPLIER:				RATE SCHEDULE:	
YR.	MO.	CONSUMPTION (KWH)	ACTUAL DEMAND (KW)	BILLING DEMAND (KW)	COST ($)
	JAN.				
	FEB.				
	MAR.				
	APR.				
	MAY				
	JUNE				
	JULY				
	AUG.				
	SEPT				
	OCT.				
	NOV.				
	DEC.				
TOTALS			———	———	
UNIT COST			———	———	

MISCELLANEOUS ENERGY CONSUMPTION

ENERGY SOURCE:							
YR.	MO.	CONSUMPTION ( )	COST ($)	CONSUMPTION ( )	COST ($)	CONSUMPTION ( )	COST ($)
	JAN.						
	FEB.						
	MAR.						
	APR.						
	MAY						
	JUNE						
	JULY						
	AUG.						
	SEPT.						
	OCT.						
	NOV.						
	DEC.						
TOTAL							
UNIT COST							

Appendix B

Implementation Analysis Form

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
Atlanta, Georgia 30332

ENERGY CONSERVATION IMPLEMENTATION ANALYSIS

Plant Code________________ Date of Report____________ Date of Analysis __________

I. Implemented ECO's:

ECO NO.	ENERGY SAVINGS			IMPL. COST	IMPL. DATE	COMMENTS
	MMBTU/YR	$/YR	A/E*			

*A = Actual, E = Estimated

II. ECO's Not Implemented:

ECO NO.	REASON FOR NOT IMPLEMENTING	IS FUTURE IMPL. PLANNED?	ANTICIPATED IMPL. DATE

A-3121

Quarterly Progress Report

Appalachian Regional Commission
Energy Conservation Program

October 1, 1981 - December 31, 1981

Submitted to:

Georgia Office of Energy Resources
and the Appalachian Regional Commission

ARC Contract No. 81-164
Ga. Tech Project No. A-3121

January 8, 1982

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

1st Quarter Activity

Reporting Period: October 1, 1981 - December 31, 1981

1. Initial Planning and Promotion:

   - An announcement of the renewal of the ARC energy conservation program was published in the December issue of the Conserver, a quarterly publication of the Georgia Tech Industrial Energy Extension Service. A copy of this publication is attached.

   - Representatives from Georgia Tech and from the Georgia Office of Energy Resources have contacted and/or visited a number of the Chambers of Commerce in the larger communities in the region. Chamber personnel were asked to identify manufacturers in their area who might be particularly hard hit by our current economic situation, and to contact these companies and inform them of the ARC program. Georgia Tech will then follow-up by contacting these plants directly. Hopefully this approach will direct technical assistance to manufacturers with the greatest need.

2. Plant Energy Surveys:

   - Two plant surveys have been conducted to date. Pertinent data on these plants is summarized below:

Plant Code	Location	Date of Plant Visit	No. of Employees	Principal Products
D2504	Toccoa	12-16-81	55	Furniture
D2004	Gainesville	12-11-81	35	Animal Proteins and Fats

3. Newsletter:

- The first edition of the bi-monthly newsletter will be published in January, and will be entitled Appalachian Energy Report. The first issue will feature a follow-up report on Universal Ceramics, a tile manufacturer surveyed under the previous ARC program. This company has installed a second heat recovery system during a recent plant expansion. Their first installation was the subject of a case study published in the November, 1980 issue of the Conserver.

4. Plans for Second Quarter:

- Approximately twelve plant surveys will be conducted
- The second issue of the Appalachian Energy Report will be published in March.
- Program promotion will continue through additional contacts with area Chambers of Commerce.

Industrial energy

CONSERVER

Published by the Industrial Energy Extension Service

Vol. 4, No. 4 December, 1981

Textile AATCC Conference Highlights Energy Conserving Techniques

by Rachel L. Moore

Several new energy conserving techniques for the textile industry were highlighted at the American Association of Textile Chemists and Colorists National Technical Conference held in Charlotte, North Carolina last month. New machinery and process modifications were featured. The new techniques are summarized below.

Combined Preparation Processes

The preparation of fabrics consumes 7% of the energy used by the textile industry, or 85 trillion Btu's each year. Over .9 billion pounds of cotton-containing fabrics are continuously prepared each year. Judging from these figures, it is surprising that more research in energy conservation for preparation has not been done. The paper presented reviews of four processes recently developed to reduce preparation energy consumption.

The most logical approach to reducing the energy consumption of preparation processes is to reduce the number of steps involved. Thus, four processes that combined desizing, bleaching, and scouring into one step were evaluated. All four processes used a pad-steam-wash sequence. The SPS and KPP processes involved the use of new chemicals in addition to hydrogen peroxide, sodium hydroxide, and sodium silicate. The AA process used two chemicals produced by a speciality chemical company along with hydrogen peroxide. The C/P process evaluated used hydrogen peroxide, sodium hydroxide, and sodium silicate in a foam.

The SPS and AA processes did not produce well prepared fabrics in a single pad-steam-wash sequence. The KPP and C/P processes produced commercially acceptable goods with comparable properties. The major difference in the two processes is that to implement the C/P process, a substantial capital investment was required while the KPP process could be adapted to existing equipment. Thus, the KPP process was chosen for further analysis.

An economic analysis was performed for a plant that prepared 28.5 billion pounds of goods each year. If all preparation processes were converted to KPP, the following savings could result:

The cost for additional chemicals was $35,900 per year, thus producing a net cost savings of $337,200 each year.

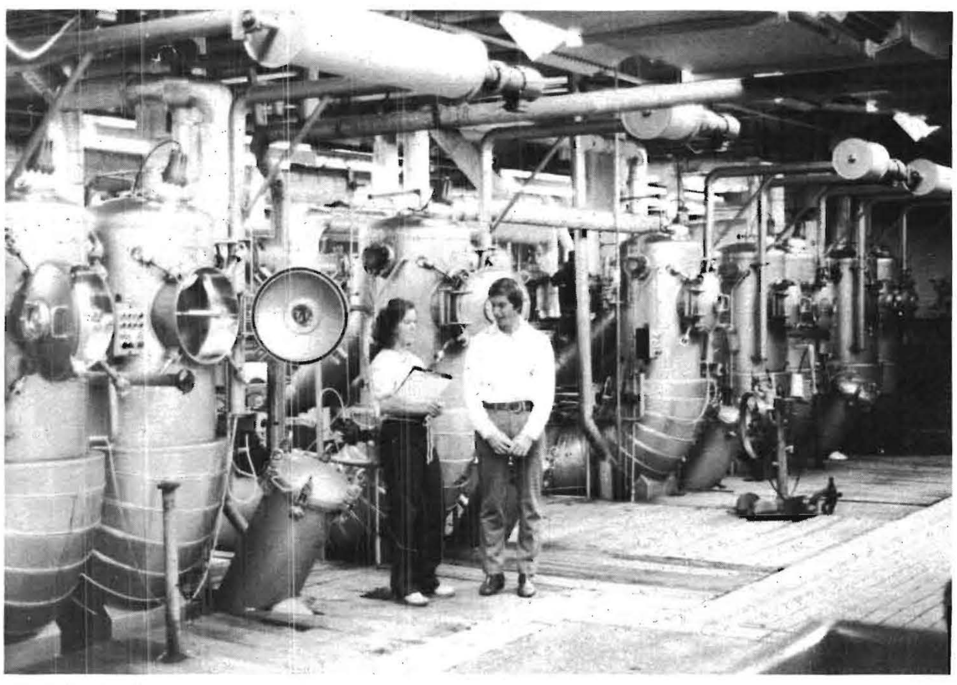
	Quantity	Cost Savings
Energy	60,500 MMBTU/yr	$340,600
Water/Sewer	32.5 million gal/yr	$ 32,500
Total		$373,100

The paper was written by the Southeastern Section of AATCC and presented in the intersectional technical paper competition where it won first place. Eleven people from Georgia Tech participated in the preparation of the paper.

Foam Finishing With a Rotary Screen

A new method of foam finishing involves using a rotary screen printing machine. Finishing previously could not be easily performed on a rotary screen printer since the chemicals were mixed with water and the use of thickeners was not acceptable for resin applications. Thus, the use of foam as a "thickener" was evaluated for

(Continued on Page 4)



STAFF ENGINEER RACHEL MOORE CONDUCTS AN ENERGY AUDIT AT A GEORGIA TEXTILE PLANT.

Simple Measures Cut Compressor Energy Costs

by Larry E. Banta

Energy conservation possibilities for process machinery can be grouped into three categories: equipment efficiency improvement, process control, and product loss reduction. The most obvious technique for reducing energy consumption in industrial processes is to improve the energy efficiency of the machinery. Many advances have been made recently in the development of more efficient motors, drive trains, compressors and pumps. Much can be done however, to improve the efficiency of existing equipment with little or no capital investment. Equipment maintenance, loading and control techniques will be examined along with new types of improved efficiency replacement and retrofit equipment.

An exact formula for compressor input power will be developed later in this section. For preliminary considerations we note that the power required is proportional to the flow rate of air and to the increase in pressure provided.

$$P \propto QX\,(P2\text{-}P1)$$

The flow rate Q and pressure rise are functions of equipment design and operating conditions, especially RPM. From the equation it can be seen that input power requirements can be trimmed by reducing either the volume flow rate or the pressure rise. It should be noted that these two quantities and the system efficiency are generally interdependent, but the trends indicated by the equation will be approximately valid.

Maintenance Measures

Volume flow rate through air compres- sors is a function of equipment load plus eakage. Compressed air leaks are a major ınd important source of energy waste in he majority of all compressed air systems. Even small pinholes can permit surprising ımounts of compressed air to escape, specially if the air is at high pressure. A /16 inch diameter pinhole would waste bout 50 cubic feet of air per hour at a line ressure of 100 psig. Air loss increases as ne square of the equivalent diameter of ne leak.

An easy method of calculating leakage sses is simply time the duty cycle of the ompressor(s) required to maintain system ressure with all air consuming equipment le. The survey could be made during on-production hours. Air leaks are generally easier to locate and repair during f-hours when reduced noise levels in the ant make leaks easy to hear.

Repairing compressed air system leaks is a simple inexpensive measure that should be routine maintenance but is often ignored. A sample caluiation shows that a dozen 1/8 inch holes in a 100 psig air system could cost up to $2,100 per year in wasted power at a cost of four cents per kWh.

Other maintenance procedures that can lead to substantial benefits are of course proper lubrication and drive maintenance, and cleaning and replacement of intake air filters. Pressure drops across dirty air filters cause a negative pressure in the compressor suction manifold thus increasing the term (P2-P1) in the equation.

A second path to reducing energy consumption in compressors is to reduce system pressure to the minimum necessary to supply equipment needs. The compressor set point pressure must be set higher than the equipment requirements to overcome pressure drops in the distribution lines. These pressure drops are proportional to the length of the lines and the square of the face velocity of the gas moving through them. Friction losses can be reduced by locating air compressors close to the largest air users, by increasing the diameter of the distribution lines and by repairing leaks which reduces the volume flow rate Q. In many instances only a few pieces of equipment require high pressure. Regulators are used to drop the system pressure for the majority of the equipment using compressed air. The feasibility of separating the systems to provide a separate high pressure supply should be determined.

Although it is not apparent from the equation, the overall efficiency of the compression process is dependent on a number of factors including the design of the compressor and the temperature of the inlet air. Standard industrial compressors are usually modeled thermodynamically as a polytropic process—that is a compromise between an adiabatic and an isothermal process in which Pv^n remains constant. Here P is pressure and v is specific volume (the reciprocal of density) and n is an exponent that lies between 1.0 (isothermal case) and 1.4 (adiabatic case). A value of n=1.35 would be a reasonable estimate for machines with cooling jackets or fins around the casing or cylinders. The theoretical work input for a polytropic compression process is approximately:

$$w = 206T1\left[\left(\frac{P2}{P1}\right)^{0.259} - 1\right] \text{ ft lbf/lbm}$$

T1 is the inlet air temperature in degrees Rankine and W is work in ft lbf per lbm. It is apparent that total work input per pound of compressed air increases with the inlet air temperature, leading to the conclusion that air compressor inlets should be placed outside the compressor power house which is usually substantially warmer than the outside. Approximately one percent reduction in compressor work input is attained for each 5°F reduction in inlet air temperature.

NEWS FLASHES

• Hank Jackson has been named the new Industrial Energy Extension Service Group Coordinator for the General Industry sector. The general industry group now includes the food and kindred products industry.

• The IEES program will be sponsoring a new workshop early next year. The workshop will be on *Waste Heat Recovery* and is scheduled for February 18, 1982 at the Atlanta Howard Johnson's Midtown Hotel. Brochures describing the event will be out later this month.

• A special report entitled "Modern Energy Conservation Techniques for the Pulp and Paper Industry" will be published by year end. It will be available on request. Please contact John Adams (404) 894-3636 or LuAnn Rockett (404) 894-3412 for more information.

Electrical Energy Workshop a Big Success

Last month, the Industrial Energy Extension Service held a one-day workshop on Electrical Energy Management. The workshop was very well attended by both commercial and industrial representatives. Vendors representing computerized EMS systems, energy efficient motors and HVAC systems were also present. The workshop covered:

- Electrical Metering and Measurement
- HVAC Operation and Maintenance
- Financing Conservation Opportunities
- EMS Systems
- Cogeneration
- Motor Performance
- Compressors and Pumps

This workshop was the first in a series which will focus on technologies as opposed to specific industry. Future topics will include Waste Heat Recovery and Process Heating.

QUARTERLY PROGRESS REPORT

APPALACHIAN REGIONAL COMMISSION
ENERGY CONSERVATION PROGRAM

January 1, 1982 - March 31, 1982

Submitted to:
Georgia Office of Energy Resources
and the Appalachian Regional Commission

ARC Contract No. 81-164
Georgia Tech Project No. A-3121

March 31, 1982

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

2nd Quarter Activity

Reporting Period: January 1, 1982 - March 31, 1982

1. Planning and Promotion

   - With the transfer of Doug Moore to a new position, LuAnn Rockett has been named project director for the remainder of the year.
   - Two copies of the "Appalachian Energy Report" were published this quarter and mailed to all applicable companies in the region. A copy of each edition is attached.
   - Chamber of Commerce personnel are beginning to send names of companies who may wish to be audited under the program.

2. Plant Energy Surveys

   Six plants were visited and four audits were completed this quarter. Pertinent data on these plants is summarized below:

Plant Code	Location	Date of Visit	No. of Employees	Principal Products
D-2214	Dalton	1-19-82	90	Carpet dyeing and finishing
D-2215	Cartersville	2-8-82	71	Textile printing
D-2505	Toccoa	3-4-82	60	Furniture
D-2004	Gainesville	2-17-82	55	Animal protein
D-2216	Dalton	3-23-82	100	Carpet dyeing
D-2217	Calhoun	3-31-82	80	Carpet manufacture

3. Plans for Third Quarter

   - The Appalachian Energy Report will be published in May, as scheduled.
   - Promotion will continue through Georgia Tech extension offices and area Chambers of Commerce.
   - Approximately nine plant surveys will be conducted.

APPALACHIAN

ENERGY REPORT

Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 1 February 1982

ARC PROGRAM RENEWED

Cost-free energy surveys will again be conducted by Georgia Tech for small manufacturers in the Appalachian region of Georgia, under a program made possible by a grant from the Appalachian Regional Commission to the Georgia Office of Energy Resources. During this funding period, Tech will continue its previous efforts, providing in-plant energy surreys to another thirty companies. Participation in the program is restricted to manufacturers with 200 or less employees. Tech engineers will emphasize energy conservation resources that can be implemented at little or no cost.

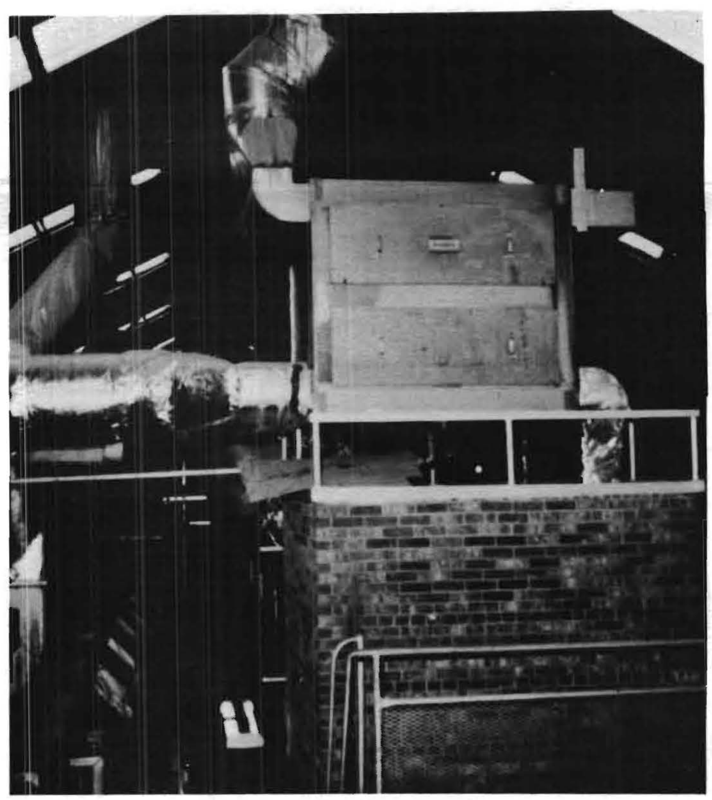
During its first year of operation, the ARC program reached almost 50 companies, and resulted in actual savings of $340,000 annually. Workshops on the fundamentals of industrial energy conservation were conducted in Gainesville and Calhoun. During the current funding period, which extends through September of 1982, a bi-monthly newsletter will be distributed to manufacturers within the region. Each issue of the newsletter will contain a case study outlining the efforts of an area manufacturer toward energy, conservation, as well as energy related news of general interest. If you would like more information on the ARC program, or if your company has an energy conservation success story that might be of interest to others in the region, please contact LuAnn Rockett at EES/TAL, Georgia Tech, Atlanta, Georgia 30332 or call (404) 894-3412.

ARC ENERGY REPORT
LuAnn Rockett, Editor

Published Bimonthly by
the Technology Applications Laboratory

TILE COMPANY INSTALLS SECOND HEAT RECOVERY UNIT

Universal Ceramics, Inc., a quarry tile manufacturer in Adairsville, Georgia, installed a second air-to-air heat recovery heat exchanger in January 1981, after achieving a 32% reduction in their gas bill from the installation of a similar unit in August 1980. Plant management were so pleased with the performance of the first heat exchanger that they decided to incorporate a second unit into the installation of a second tile kiln and dryer. The combined effect of the two heat recovery systems allowed Universal to double their production without doubling natural gas usage.



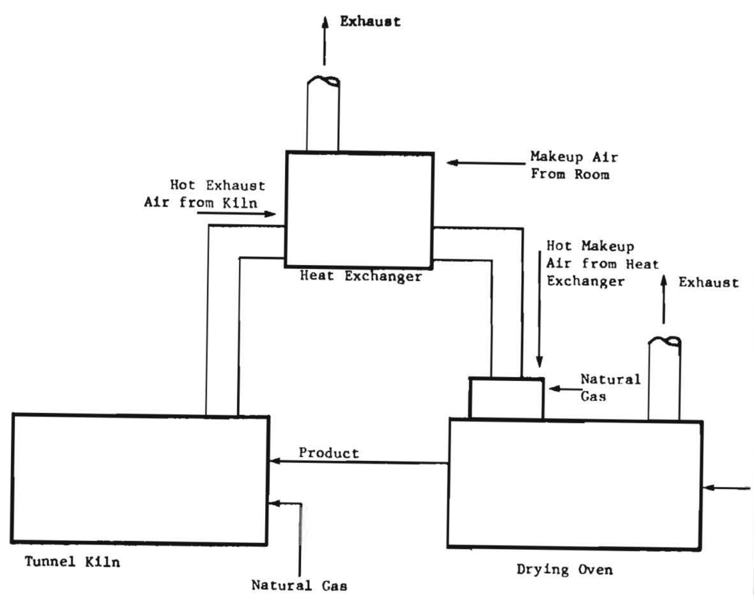
Universal's Heat Recovery Unit

In making quarry tile, shale from a nearby quarry is ground, wetted, and extruded into a continuous strip that is cut into lengths. The rough pieces are dried in a long tunnel type oven at relatively low temperatures (320^{o}F max.), reducing the moisture content from approximately 19% to 0.5%. The dried tiles are then fired in a high temperature tunnel kiln (1800^{o}F) to produce an impervious ceramic product. The drying and firing are both energy intensive processes, using natural gas as the energy source. Prior to installation of the first heat recovery system, Universal consumed over 17 million cubic feet of natural gas each year.

The heat recovery installations at Universal Ceramics use the heat energy in the kiln exhaust gases to preheat the make-up air introduced into the dryer. The air-to-air heat exchanger is a counterflow plate type device that transfers energy from the exhaust air stream to the fresh air stream via the mechanism of conduction through the metal plates. This type unit provides positive separation of the two air streams, preventing moisture and other contaminants present in the kiln exhaust from entering the dryer. The heat recovery systems were engineered by Mr. John English of Resh and Redd Inc., in Atlanta.

The efficiency of the first heat recovery unit installed at Universal was 64%. This figure is typical for a cost-effective industrial application where efficiencies normally range between 60% and 70%. Efficiencies as high as 80% can be obtained with this type of device; however, the additional heat exchange surface area required often raises the cost to prohibitive levels.

The original heat recovery system at Universal was installed at a total cost of \$13,000. At that time, savings in natural gas amounted to over \$1,900 per month, resulting in a payback of less than seven months. The second system, which utilizes an identical Z-Duct heat exchanger, was installed at a cost of approximately \$2000 less than the first, since the heat recovery unit was installed with the new kiln and dryer. The peformance of second unit has been comparable to the first, resulting in an overall plant energy savings of roughly 30%. Plant personnel have reported no loss of efficiency in either unit since their installation.



Heat Recovery Unit Schematic

Technology Applications Laboratory
Engineering Experiment Station
Georgia Tech
Atlanta, Georgia 30332

APPALACHIAN

ENERGY REPORT

Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 2

March 1982

Textile Firm Counterflows Oven Exhaust

A north Georgia textile manufacturer recently modified two heatsetting ovens to counterflow the exhaust air. The result was a significant reduction in the amount of air exhausted, and a corresponding reduction in the amount of air taken into the oven that had to be heated to the operating temperature. Gas consumption to the ovens was reduced by over 50%.

The textile operations of drying, curing, and heatsetting are commonly performed in ovens, in which thermal energy is transferred to the textile material by controlled convective heat transfer using air as the heat transfer medium. Most tenter frames and ovens in use today were designed and built when energy costs did not make a significant impact on the cost of a finished textile product, and are consequently not energy efficient. There are several modifications that can be made to existing ovens and tenter frames that will reduce the energy requirements of these thermal processes and do not require a large capital investment. One method that has proved to be effective is the counterflowing of air through the dryer housing.

In a typical textile tenter oven there are several heating zones. Each zone is equipped with a burner or steam coils, and has its own make-up air inlet and exhaust stack. Air is exhausted from the stacks to remove vaporized water and sometimes smoke, particulate matter, or solvents. The amount of hot air exhausted from each zone usually controlled by the speed of the fan installed in the duct, and is normally of a much higher volume than necessary to meet process requirements. The exhausted air usually does not contain as much moisture or other matter as it should before it is exhausted. Thus, the drying or heating capacity of the air is not fully utilized. Since the exhausted air must be replaced by fresh make-up air that must be heated to the oven temperature, exhausting excessive amounts of hot air represents a substantial energy loss. Therefore, a reduction in the exhaust air flow via counterflowing the oven air can result in substantial energy savings.

ARC ENERGY REPORT
LuAnn Rockett, Editor

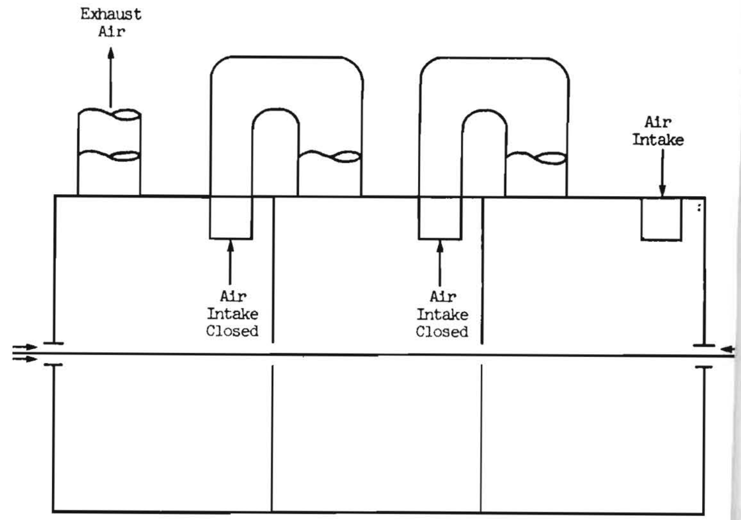
Published Bimonthly by
the Technology Applications Laboratory

The principle of counterflowing oven exhaust air involves having the cleanest air contact the material that is closest to being finished (this includes drying, curing, and heat setting). Make-up air enters the oven at the product exit end, flows opposite the flow of goods, and is exhausted at the product entrance end. Many new ovens are designed to counterflow as a part of the original operating mechanism. However, for older ovens, some engineering modifications must be made to the exhaust and air intake systems to make the air flow properly. The exhaust stack of each zone can be ducted into the make-up air inlet of the preceding zone, with air taken in only at the last zone and exhausted only at the first zone, as shown in Figure 1. This was the modification made at Plant 22054. Another method would be to simply block off the exhaust stacks for all but the first zone and the make-up air inlets for all but the last zone. This method is simpler, but not as effective as the first method.

The energy consumption for one of the heat setting ovens was measured before and after the counterflow modification was made. The oven typically processed 12 foot wide fabric at an average speed of 80 yards per minute. The measurements revealed that the counterflow modification reduced the energy consumption of the oven by 56%. The results are shown below:

	Energy Consumption
Before Modification	1.968 MMBTU/hr
After Modification	0.867 MMBTU/hr
Energy Savings	1.101 MMBTU/hr

For an average natural gas cost of $3.20 per MMBTU, the annual energy cost savings were $29,595. The capital cost for modifying the oven was $22,865, thus resulting in a pay back period before taxes of 9 months. Based on the excellent results of the first oven conversion, the second oven was also modified.



OVEN WITH COUNTERFLOW MODIFICATION

ARE YOUR ENERGY COSTS OUT OF SIGHT?

If you are interested in reducing your energy costs, complete the form below for a free and confidential energy audit of your plant. Return to:

Ms. LuAnn Rockett
Georgia Tech
EES/TAL/ECD
Atlanta, Georgia 30332

Company Name: ______________________

Address: ______________________

Company Contact: ______________________

Title: ______________________

No. of Employees: ______________________

Technology Applications Laboratory
Engineering Experiment Station
Georgia Tech
Atlanta, Georgia 30332

QUARTERLY PROGRESS REPORT

APPLACHIAN REGIONAL COMMISSION

ENERGY CONSERVATION PROGRAM

April 1, 1982 - June 30, 1982

Submitted To:

GEORGIA OFFICE OF ENERGY RESOURCES

and the

APPLACHIAN REGIONAL COMMISSION

ARC Contract No. 81-164
Georgia Tech Project No. A-3121

June 30, 1982

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

3Rd Quarter Activity

Reporting Period: April 1, 1982 - June 30, 1982

1. Planning and Promotion

   - A new engineer, Richard Steenblik, has been added to the project staff on a part-time basis.

   - Two copies of the "Appalachian Energy Report" were published this quarter and mailed to all applicable companies in the region. A copy of each edition is attached.

   - Promotion through various Chamber of Commerce offices is continuing.

2. Plant Energy Surveys

   Eight plants were visited and five audits were completed. Pertinent data on these plants is summarized below:

Plant Code	Location	Date of Visit	No. of Employees	Principal Products
D-2506	Gainesville	4/8/82	80	Furniture
D-2218	Ellijay	4/19/82	170	Carpet
D-3204	Canton	4/22/82	80	Aquariums
D-3004	Dalton	5/11/82	55	Carpet Backing
D-2005	Rome	5/25/82	80	Flour
D-2301	Bowdon	5/27/82	110	Men's Apparel
D-3902	Lawrenceville	6/18/82	26	Toy Cars
D-2219	Cartersville	6/22/82	171	Carpet

3. Plans for 4th Quarter

   - The Appalachian Energy Report will be published in September, as scheduled.

   - Promotion will continue through Georgia Tech Extension offices and area Chambers of Commerce.

   - Approximately eight plant surveys will be conducted.

APPALACHIAN

ENERGY REPORT

Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 3 May 1982

AM FINISHING SAVES $260,000

Foam finishing is a process whereby the finish is applied to the fabric in an air-blown foam, rather than a pure liquid state. This results in the following advantages over conventional aqueous systems:

- Reduction in energy consumption for drying and curing per pound of fabric,
- More efficient use of chemicals,
- Application to wet fabric without first drying, and
- Reduction in water content of the finish resulting in higher production rates, decreased dryer temperatures and decreased fuel consumption.

To date, foam finishing has gained ider acceptance than foam dyeing, mainly ecause of the wider latitude in uniformity llowed for colorless finishes than for yes and pigments. Foam finishing can also esult in the elimination of the washing nd drying steps after curing, another xample of the energy savings possible with oam finishings.

raditional Operation

An apparel plant has been successfully sing foam finishing since 1977. The plant produces fabrics ranging from 1.2 to 4.0 yards per pound. The average fabric weight is 2.5 yards per pound. The fabrics are generally 50% polyester/50% cotton blends, with polycellulosics accounting for 80% of the total production. All fabrics produced in the plant are finished with foam processing.

ARC ENERGY REPORT
LuAnn Rockett, Editor

Published Bimonthly by
the Technology Applications Laboratory

Until 1977, the plant operated with conventional finishing ranges. The ranges typically ran at 40 to 80 yards per minute, and generally consumed 32 yards per gallon of finishing mix. Drying and curing temperatures ranged from 350° to 375°F when performed in the same step. During this time, total plant gas consumption in the finishing area was 23,100 MMBtu at an average annual cost of $2.61 per MMBtu.

Modifications

In 1977, the conventional finishing ranges were retrofitted with foam systems at an average cost of $25,000 per range. The incentives to invest were two-fold -- projected energy savings and increased production.

The system is shown in Figure 1. Using this type of foam finishing technology, both sides of the fabric are finished at the same time. Production speeds have been increased to 70 to 110 yards per minute using foam finishing, and plant personnel project that with new drying equipment, speeds of over 200 yards per minute can be achieved. Using foam, the wet pick-up has averaged 25% to 35%.

Foam finishing has led to a decrease in chemical usage of 10% to 20%. A typical finish can now be applied at 100 yards per gallon of mix. Energy consumption for finishing has been reduced to 10,100 MMBtu for 1980 at a cost of $5.01 per MMBtu.

Savings

The initial $25,000 invested in the system was recovered in 25 weeks with $1000 per week in savings due to the decrease in energy consumption. Because the total payback period was so short, the investment was made without any consideration given to return on investment or other economic analyses. Total finishing energy consumption is shown in Table I.

Total savings dollars are based on labor, materials and overhead costs. Energy consumption is also included in this figure. Based on current plant figures, the average savings shown in Table II were compiled.

Table I

TOTAL FINISHING ENERGY CONSUMPTION

	Propane Cost	Energy Usage	Total
Conventional (1977)	$0.249/gal	925 BTU/yd	2.31×10^{10} BTU
Foam (1980)	$0.479/gal	405 BTU/yd	1.01×10^{10} BTU
SAVINGS		520 BTU/yd	13,000 MMBtu/y

Table II

TOTAL FINISHING COST SAVINGS

	Annual	Weekly Average
ENERGY SAVINGS	$ 65,150	$ 1,303
TOTAL SAVINGS	$260,150	$ 5,203

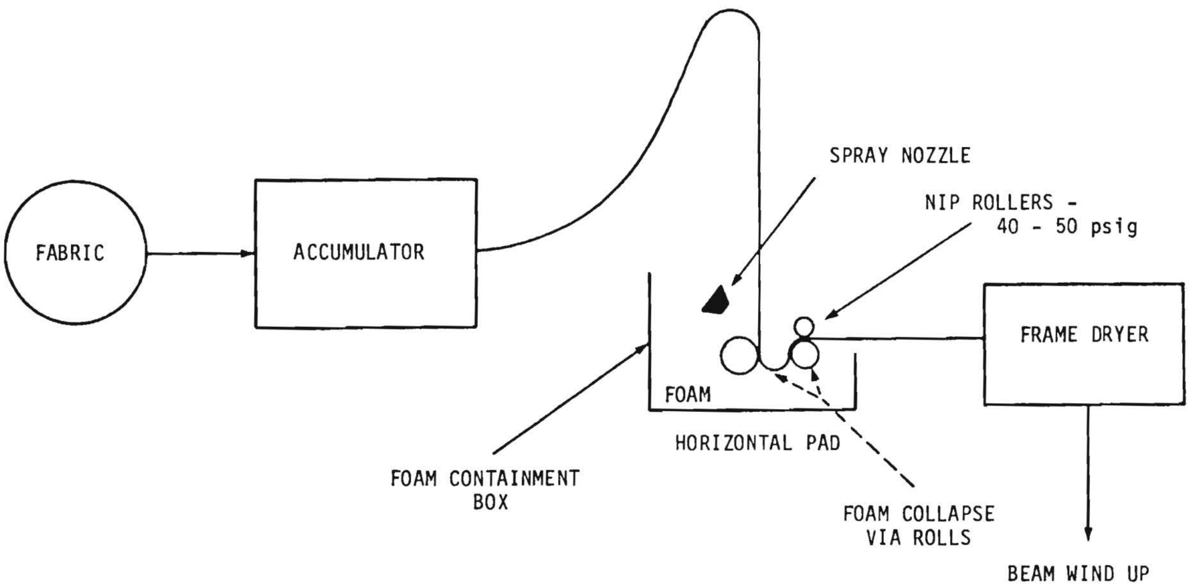


Figure 1. Foam Finishing System

Technology Applications Laboratory
Engineering Experiment Station
Georgia Tech
Atlanta, Georgia 30332

APPALACHIAN
ENERGY REPORT
Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 4 July 1982

mproving Boiler Operating Efficiency

One of the more effective means of improving and maintaining boiler operating efficiency is a boiler tune-up. This preventive maintenance item is one of the most direct approaches to fuel conservation through efficiency improvement.

The primary objective in a tune-up is to achieve efficient combustion with a controlled amount of excess air. Operating with the lowest practical excess air will minimize exhaust losses by reducing the quantity of unneeded air that is heated to temperature and then not utilized. The associated reduction in stack gas temperature and power consumption by forced draft and induced draft fans are additional benefits. The actual improvement in boiler efficiency with lower excess air depends on the initial stack temperature and excess air. A given change in excess air will have a greater effect when stack temperatures are high.

Proper operation of the boiler combustion control system is essential for maintaining high boiler operating efficiencies and low excess air levels. Its main purpose is to provide the correct quantities of fuel and air at the burner to satisfy a varying demand for steam generation. Although it is important that the excess air delivered to the burner be kept to a minimum over the boiler operating range, it generally is not practical to operate precisely at the point of maximum efficiency. This optimum typically occurs at the threshold of combustible or smoke formation and may result in unacceptable stack conditions. For most boilers, it is necessary to maintain a margin of excess air above the minimum or threshold level to accommodate variations in fuel properties and ambient conditions, non-repeatability of control settings, normal deterioration of control parts, and rapid changes in firing rate.

ARC ENERGY REPORT
LuAnn Rockett, Editor

Published Bimonthly by
the Technology Applications Laboratory

To assure reliable, safe, and efficient boiler performance, manufacturers of boiler and burner equipment recommend periodic inspections and tune-ups. Thorough tune-ups are recommended annually, but many operators also prefer to conduct quick boiler efficiency checks much more often, sometimes on a daily or weekly basis (as mentioned in the previous section on performance monitoring). Thus, efficiency problems can be detected before large fuel wastes occur or expensive maintenance is required. Boiler tune-up services are also available from most major manufacturers of boiler and burner systems, some local utilities, and engineering consulting firms. For boiler operators desiring a basis efficiency check of their boiler, the local natural gas supply company may provide this service at little or no charge to customers and may also offer some assistance in adjusting burner controls for peak efficiency.

A minimal tune-up should include a verification of automatic fuel and air control operation over their operating range. Visual furnace observations and stack measurements of O_2, CO, CO_2 and temperature are essential elements in this type of tune-up. It is important that excess air not be reduced at the expense of excessive combustibles (unburned fuel, carbon carryover, CO, etc.) since these can represent significant efficiency losses. More than 400 ppm carbon monoxide (CO) in the stack gases in generally not acceptable.

Water Quality Control and Blowdown

Water treatment is an important aspect of boiler operation that can affect efficiency or result in plant damage if neglected. Boiler feedwater contains impurities in solution and suspension. These impurities concentrate in the boiler water since the steam generated is essentially pure. If these suspended solids are allowed to concentrate beyond certain limits, a deposit or scale will form on the boiler heating surfaces which will retard heat transfer and increase tube metal temperatures. This can lead to increased stack gas temperatures that reduce boiler efficiencies. Even more important is the probability of furnace tube failures from overheating as a result of the insulating effect of water-side scale.

Chemical treatment of the boiler water is necessary to counteract the adverse effects due to concentration of impurities introduced with the makeup water. Blowdown is required to reduce the build-up of impurities and expended chemcials. Thus, the amount of blowdown required is dependent on the type and operation of equipment, impurities in the make-up water, and the make-up water addition rate.

Other areas that should be considered with a boiler maintenance program are:

- Combustion efficiency spot checks
- External tube cleanliness
- Boiler insulation
- Flue gas heat recovery
- Load balancing
- Reduced boiler steam pressures
- Condensate return
- Steam leaks
- Steam traps

For more information on these specific topics, contact the ARC program at (404) 894-3412.

Technology Applications Laboratory
Engineering Experiment Station
Georgia Tech
Atlanta, Georgia 30332

QUARTERLY PROGRESS REPORT

APPALACHIAN REGIONAL COMMISSION
ENERGY CONSERVATION PROGRAM

July 1, 1982 - September 30, 1982

Submitted To:

GEORGIA OFFICE OF ENERGY RESOURCES

and the

APPALACHIAN REGIONAL COMMISSION

ARC Contract No. 81-164
Georgia Tech Project No. A3121

September 30, 1982

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

3rd Quarter Activities

Reporting Period: July 1, 1982 - September 30, 1982

1. Planning and Promotion

   - Two new engineers, Carol Aton and Robert Didocha, have been added to the project staff on a part-time basis.

   - A no-cost extension through December 31, 1982 has been requested.

   - Promotion through various Chamber of Commerce offices is continuing.

2. Plant Energy Surveys

   Five plants were visited and five audits were completed. Pertinent data on these plants is summarized below:

Plant Code	Location	Date of Visit	No. of Employees	Principal Products
D-3005	Tallapoosa	7-23-82	109	Rubber
D-2507	Cumming	8-13-82	50	Telephone Booths
D-3006	Lawrenceville	9-8-82	197	Food Trays
D-2302	Helen	9-10-82	115	Ladies' Slacks
D-2303	Mountain City	9-16-82	143	Men's Slacks

3. Plants for 4th Quarter

   - The Appalachian Energy Report will be published in November, as scheduled.

   - Promotion will continue through Georgia Tech Extension offices and area Chambers of Commerce.

   - Ten plant surveys will be conducted in order to meet the project goal of 30.

   - A final report will be written.

   - A new project director will be named, as LuAnn Rockett will be leaving Georgia Tech.

FINAL REPORT – 1982

ENERGY CONSERVATION ASSISTANCE TO GEORGIA APPALACHIAN INDUSTRIES

By

Richard A. Steenblik

Submitted to

GEORGIA OFFICE OF ENERGY RESOURCES

and

THE APPALACHIAN REGIONAL COMMISSION

January 1983

GEORGIA INSTITUTE OF TECHNOLOGY

A Unit of the University System of Georgia

Engineering Experiment Station

Atlanta, Georgia 30332

1983

ENERGY CONSERVATION ASSISTANCE TO GEORGIA APPALACHIAN INDUSTRIES

FINAL REPORT - 1982

Submitted to:

Georgia Office of Energy Resources
and the Appalachian Regional Commission

Prepared by:

Richard A. Steenblik

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

January, 1983

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

An industrial energy conservation program has been sponsored by the Appalachian Regional Commission since 1980, and administered by the Georgia Office of Energy Resources. Under this program, in-plant energy surveys have been provided to small manufacturing firms with 200 employees or less in the Appalachian region of Georgia. Thirty surveys were performed in 1980, and an additional thirty surveys were performed during the 1982 program year. This report summarizes the activities of the Technology Applications Laboratory of Georgia Tech's Engineering Experiment Station during the 1982 program period.

Six newsletters were published and distributed to over 1200 plants in the Georgia Appalachian region during 1982. The newsletters contained case studies and energy conservation opportunities, including the successful retrofit of a heat recovery unit to a quarry tile kiln, the conversion of a textile tenter oven from zoned heating to a counterflow arrangement, recommendations for improving boiler efficiency, and a discussion of the merits of roof spray cooling systems.

The thirty manufacturing plants surveyed during 1982 consumed a total of 957 billion BTU's annually, at a cost of over 5.6 million dollars. The survey reports sent to these firms contained 124 conservation recommendations estimated to save 143 billion BTU's and more than $800,000 at current energy costs ($27,805 average savings per plant). As of the date of this report, the seventeen plants contacted by telephone survey report that they have implemented 47 of the 78 recommendations made to them. The implemented recommendations resulted in actual savings amounting to 73.7 billion BTU's and $453,703 ($315,123 average savings per plant). Based on the detailed implementation data from these 17 plants, it is estimated that the total implementation for all 30 plants will be 75 of the 124 recommended ECO's. This could result in actual savings of 95.6 billion BTU's and $542,651 ($18,088 average savings per plant). Implementation data on the remaining 13 plants are being gathered and analyzed to provide revised totals.

If the program cost of $79,784 is included with the client cost of implementation, the savings/investment ratio of the overall program is 2.44. Based on program cost alone, every Appalachian Regional Commission dollar invested in energy conservation in the Georgia ARC region can result in energy savings worth $6.80.

Although accomplishments under this program have been substantial, only about 3.3% of the industrial population of the ARC region has been reached during the two-year period of the program's existence. Expansion of the program to reach 50 percent of the industrial population could result in potential savings of more than 4,200 billion BTU's and 25 million dollars annually. Savings of this magnitude could have a very significant impact on the economy of the Appalachian region.

Reaching 50 percent of the industrial population will require a considerable effort. Individual plant energy audits should continue, as well as documentation and dissemination of case studies of successful energy conservation efforts in industry. In addition, workshops and expos should be held to present large numbers of plants with more general energy conservation information. Two energy conservation expos are suggested for the program plan in 1983. The expos will introduce attendees to energy conserving equipment and practices, and will provide instruction on energy housekeeping and on financing energy conservation measures. It is anticipated that these expos will be attended by 200 persons representing Appalachian region industries.

II. INTRODUCTION

Conservation is an essential element of our national energy program, and has often been considered to be the most immediate, practical, and cost effective means of reducing our dependence on imported oil and preventing future energy shortages. The Energy Conservation Branch of the Technology Applications Laboratory, a major organizational branch of the Georgia Tech Engineering Experiment Station, has been heavily involved in the field of industrial energy conservation since 1977. Through the Appalachian Regional Commission sponsored program, engineers have provided valuable technical assistance to small manufacturers with 200 employees or less in the 35 county Appalachian region of Georgia.

The primary goal of the program was to assist area industries in reducing or at least containing their spiraling energy costs. The major efforts of the program were concentrated in two primary activities: (1) in-plant energy surveys followed by written survey reports, and (2) technical information transfer through distribution of a bi-monthly newsletter.

A total of thirty in-plant energy surveys were conducted and reports prepared. Because of the small size of the companies involved, a one-day visit was normally adequate. Emphasis was placed on recommendations requiring little or no capital expense such as turning out lights or resetting controls, although the greatest savings normally resulted from more capital-intensive projects. The surveys were very effective in terms of the energy savings accomplished, as explained in detail in section III of this report.

In order to reach a broader audience, six bi-monthly one-page Appalachian Energy Reports were distributed to each manufacturer in the Appalachian region. These newsletters contained case studies of energy conservation measures implemented by manufacturers in the Appalachian region, and energy conservation recommendations which have broad application. In addition, each plant in the region received copies of the Conserver, a quarterly newsletter produced by Georgia Tech under the Industrial Energy Extension Service (IEES) program, a statewide conservation program sponsored by the Georgia Office of Energy Resources. Representative copies of these publications are included in the Appendix of this report.

Annual energy consumption by the industrial sector of the Georgia Appalachian Region amounted to approximately 135,000 billion BTU's (in 1980), or roughly 38% of the total energy consumption of the region. The total energy consumption of the 30 plants surveyed amounted to 957 billion BTU's, or about 1% of the area's total industrial consumption. A survey of the industrial population indicates that there are approximately 1,800 manufacturing plants in the region. The thirty plants surveyed under this year's program represent only 1.7 percent of this population. The previous ARC audit program, conducted in 1980, surveyed an additional thirty plants, so the total number of plants surveyed represent 3.3 percent of the Appalachian region industrial population. Although the energy and cost savings obtained under the program are substantial, they represent only a very small portion of the potential savings that might be realized.

In order to facilitate common comparison of various different types of industrial energy sources, a common energy unit, BTU, is used in this report. The abbreviation MMBTU is used to indicate million BTU's.

III. PLANT ENERGY SURVEYS

A total of thirty audits were completed during 1982. Client companies were selected through one of two channels: direct requests from companies who had learned of the program and contacted Georgia Tech and by random telephone solicitation. The program was advertised through the first three bi-monthly Appalachian Energy Reports, distributed to over 1,200 area manufacturers. Any company requesting an energy survey was given one; however, over half of the audits were scheduled by calling prospective clients, informing the appropriate company official of the service, and offering to perform an audit. Response to this approach was good, in that most companies contacted wanted to take advantage of the program. It has been suggested by observation that the companies who requested assistance were more likely to implement the suggestions made in the audit report than those companies for which Georgia Tech made the initial effort, although no statistics were compiled. On the other hand, solicitation of selected companies allowed emphasis to be placed on the larger or more energy intensive industries where much higher energy savings per program dollar were possible.

Description of Surveyed Plants

Table III-1 provides a breakdown of the mix of industries for which ARC audits were performed. That the textile industry dominates is a reflection of two factors, (1) it is one of the largest industry groups in the state, especially in the Appalachian Region, and (2) it is a very energy intensive industry with which Georgia Tech researchers have much experience and a good working relationship. Table III-2 gives an indication of the range of company sizes for which work was done. The average plant employed about 89 people and worked two shifts per day year-round. The geographic distibution of audited plants in the ARC region is depicted in Figure III-1.

The thirty plants spent a combined total of $5.6 million for more than 957 billion BTU's of energy last year. Table III-3 breaks this useage down by fuel type and shows that more than 80% of the BTU consumption was of "thermal" fuel: natural gas, propane, or oil. Slightly less than 20% of the BTU's consumed were supplied by electricity but due to its high cost,

TABLE III-1

PROFILE OF AUDITED COMPANIES

Product Type	SIC Group	No. of Companies
Food Products	20	3
Textile Mill Products	22	9
Apparel	23	3
Furniture	25	5
Rubber & Plastics	30	3
Stone, Clay, Glass, Concrete	32	1
Fabricated Metals	34	1
Electrical Equipment	36	3
Instruments	38	1
Miscellaneous	39	1

TABLE III-2

GENERAL DATA SUMMARY TABLE

Characteristics	Average	Range Min.	Range Max.	Total
No. of Employees	89	5 -	213	2,674
Hours Operation Per Year	3,739	1,872 -	8,736	-
Annual Energy Use Per Employee - MMBTU	365	28 -	4,499	-
Total Energy Consumption - MMBTU	31,905	739 -	404,913	957,187

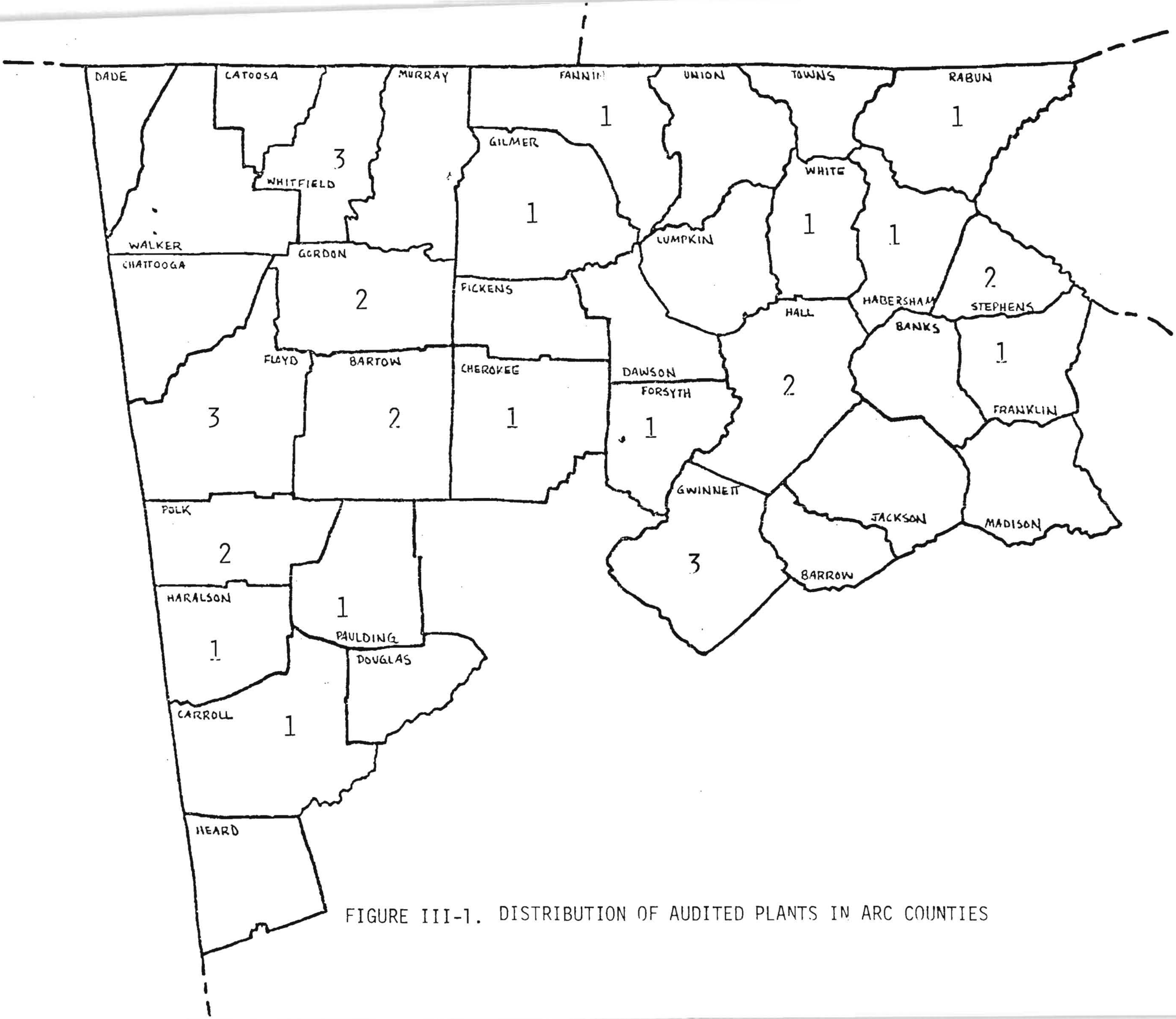


FIGURE III-1. DISTRIBUTION OF AUDITED PLANTS IN ARC COUNTIES

TABLE III-3

ENERGY USAGE BY SUPPLY SOURCE

Utilities	Average Usage Per Plant		Total Usage		Unit Cost	% of Total Energy Usage	
	MMBTU	Dollars	MMBTU	Dollars	Dollars Per MMBTU	Energy Basis	Cost Basis
Electricity	6,172	82,411	185,173	2,472,342	13.35	19.3	43.8
Natural Gas	24,008	95,449	720,256	2,863,484	3.98	75.3	50.7
Sub-Total (Avg.)	30,180	177,860	905,429	5,335,826	5.88	94.6	94.5
No. 2 Fuel Oil	338	2,212	9,815	64,159	6.54	1.0	1.1
No. 5 Fuel Oil	1,066	5,988	30,930	173,666	5.61	3.2	3.1
Propane	379	2,623	11,013	76,075	6.91	1.2	1.3
Sub-Total (Avg.)	1,783	10,823	51,758	313,900	(6.06)	5.4	5.5
TOTAL (Avg.)	31,963	188,683	957,187	5,649,726	(5.90)	100.0	100.0

relative to other energy forms, it accounted for nearly 44% of the total energy costs of the companies visited.

Recommended Energy Conservation Opportunities

The thirty energy audits compiled a total of 124 Energy Conservation Opportunities, or ECO's. Table III-4 provides a breakdown of the number and type of ECO's that were recommended in the reports. A key to the ECO types used in the table follows:

1. Lighting: delamping, relamping with higher efficiency bulbs, cleaning skylights.
2. Compressed Air Systems: repairing leaks, reducing system pressure, relocating intakes.
3. Steam Systems: repairing leaks and faulty traps, reducing system pressure, boiler tune-up, economizers, insulating pipes, condensate return.
4. Waste Heat Reduction and Recovery: insulation of equipment, waste stream heat recovery, dryer tune-up, dye bath reuse, bump and run dyeing.
5. Building Environmental Control: building insulation, weatherstripping, thermostat setback, dock seals, system balancing.
6. Overall Plant Energy Management: turn off unused equipment, rearrange production sequence, turn off pilot lights in auxilliary boilers, etc.
7. Energy-Efficient Equipment: substitution of energy efficient equipment for older models. Does not include lighting.

As Table III-4 shows, these recommendations if implemented could conserve an estimated 143 billion BTU equivalent per year for the thirty surveyed plants, for an overall savings of 15 percent. The dollar savings potential is more than $800,000 annually at current fuel prices.

Category 4 (heat conservation and recovery) contains the largest recommended savings, accounting for 53% of the total BTU savings. This

TABLE III-4

COMMON TYPES OF POTENTIAL ENERGY CONSERVATION OPPORTUNITIES

Type	No. of ECO's	Conservation Potential MMBTU's	Conservation Potential $	Percentage of Total Savings BTU Basis	Percentage of Total Savings $ Basis	Average Savings MMBTU/YR	Average Savings $
1	28	2,812	40,643	1.96	4.87	100	1,452
2	8	384	3,162	0.27	0.38	48	395
3	18	26,759	110,364	18.70	13.23	1,487	6,131
4	15	74,925	372,390	52.35	44.64	4,995	24,826
5	18	7,585	44,840	5.30	5.38	421	2,491
6	20	24,522	179,586	17.13	21.53	1,226	8,979
7	17	6,136	83,178	4.29	9.97	361	4,893
Totals	124	143,153	834,163*	100	100		

*This number does not include demand control savings as does the total in Table III-5.

points out the tremendous potential for waste heat recovery as an industrial conservation measure.

Table III-5 presents the energy conservation potential of the recommendations on the basis of energy source. Electrical conservation accounts for only 13.5% of the total BTU savings, although more than half of the ECO's written were electrical conservation measures. The potential dollar savings for electrical conservation is much greater, 33.4% of the total, due to the higher cost of electricity per BTU than other energy sources.

TABLE III-5

ENERGY CONSERVATION POTENTIAL BY ENERGY SOURCE

	Conservation Potential		Percentage of Total Savings			Average Savings/ECO	
	MMBTU/Yr	$	BTU Basis	$ Basis	No. of ECO's	MMBTU/Yr	$
Electricity	19,353	292,152	13.5	33.4	91	213	3,210
Natural Gas	73,451	523,795	51.3	60.0	57	1,289	9,189
Fuel Oil	48,838	49,426	34.2	5.7	12	4,070	4,118
L.P.G.	1,481	8,299	1.0	.9	7	211	1,185
Totals	143,123	873,672	100	100	167*		

*This number is inflated by ECO's which conserve more than one fuel type, as in the case of energy management.

Implementation of Energy Conservation Opportunities

Industry response to the conservation recommendations has been encouraging. Table III-6 presents the implementation data for the 17 plants for which implementation data has been obtained. Table III-7 presents the same information extrapolated to include the remaining 13 plants. Actual implementation data is being obtained from these 13 plants, and will be used to complete Table III-6 when all responses have been obtained. A revised Table III-6 will be submitted to ARC when completed. Table III-6 shows that a total of 47 ECO's, or 59% of the ECO's written to the 17 plants have either been implemented or firmly committed to. The actual savings for these 17 plants is 73.7 billion BTU's and $453.703 each year. When this data is extrapolated to include all 30 plants, as shown in Table III-7, it is projected that a total of 75 ECO's will be implemented, with a corresponding actual savings of 95.6 billion BTU's and $542,651 each year.

The percentages of achieved BTU and dollar savings are even more encouraging, with 67% of the recommended BTU savings and 72% of the recommended dollar savings reported as implemented. These figures reveal a strong willingness to conserve energy by these plants, with special attention given to those ECO's which save the most money.

A breakdown of recommended and implemented ECO's according to energy type is given in Table 8 for the 17 plants, and extrapolated to include all 30 plants in Table 9. Table 8 indicates that the greatest actual BTU and dollar savings resulted from ECO's which conserved natural gas. The total actual energy savings were 11 times higher for natural gas than electricity for the 17 plants, and the dollar savings were 3 times higher for natural gas over electricity. These large differences are expected to moderate when implementation data on all 30 plants is compiled, as shown in Table 9. It is expected that actual BTU savings for natural gas will be almost five times electrical BTU savings, with natural gas dollar savings twice electricity dollar savings. These changes reflect the change in the total number of ECO's recommended for a given fuel.

TABLE III-6

RECOMMENDED AND IMPLEMENTED ENERGY CONSERVATION OPPORTUNITIES BY CATEGORY*

ECO Type	Number of ECO's Recommended	Number of ECO's Implemented	%	Energy Savings - MMBTU Recommended	Energy Savings - MMBTU Implemented	%	Dollar Savings Recommended	Dollar Savings Implemented	%
1 (Lighting)	16	11	63	1,831	1,224	67	25,499	15,601	61
2 (Comp. Air)	5	2	40	246	45	18	1,352	534	39
3 (Steam)	7	5	71	15,413	11,813	77	62,825	50,646	81
4 (Waste Heat)	9	6	67	63,057	51,507	82	325,097	286,407	88
5 (Building Environm.)	12	8	67	5,553	3,408	61	31,392	22,476	72
6 (Energy Managemt)	20	11	55	21,062	4,237	20	160,046	60,857	38
7 (Efficient Equipment)	11	5	45	4,237	1,458	34	27,892	16,912	61
Total (avg.)	80	47	(59)	109,433	73,672	(67)	634,103	453,703	(72)

*Based on 17 implementation survey respondents.

TABLE III-7

RECOMMENDED AND IMPLEMENTED ENERGY CONSERVATION OPPORTUNITIES BY CATEGORY*

ECO Type	Number of ECO's Recommended	Number of ECO's Implemented	Energy Savings - MMBTU Recommended	Energy Savings - MMBTU Implemented	%	Dollar Savings Recommended	Dollar Savings Implemented	%
1 (Lighting)	28	18	2,812	1,884	67	40,643	24,792	61
2 (Compressed Air)	8	3	384	69	18	3,162	1,233	39
3 (Steam)	18	13	26,759	20,604	77	110,364	88,395	81
4 (Waste Heat)	15	10	74,925	61,439	82	372,390	327,703	88
5 (Building Environment)	18	12	7,585	4,627	61	44,840	32,285	72
6 (Energy Management)	20	11	24,552	4,910	20	179,586	68,243	38
7 (Efficient Equipment)	17	8	6,136	2,086	34	83,178	50,738	61
Total (avg.)	124	75	143,153	95,619	(67)	834,163	542,651	(65)

*Extrapolated data from Table III-6 and audit report recommendations to include all audited plants.

TABLE III-8

RECOMMENDED AND IMPLEMENTED ENERGY CONSERVATION OPPORTUNITIES BY ENERGY TYPE*

Energy Source	Number of ECO's Recom-mended	Number of ECO's Imple-mented	%	Energy Savings - MMBTU Recom-mended	Energy Savings - MMBTU Imple-mented	%	Dollar Savings Recom-mended	Dollar Savings Imple-mented	%
Electricity	52	30	58	11,008	5,875	53	153,468	70,707	59
Natural Gas	37	21	57	95,190	64,596	68	461,645	344,108	75
Fuel Oil	5	4	80	3,039	3,005	99	17,798	17,786	99.9
LPG	4	4	100	196	196	100	1,102	1,102	100
Total (avg.)	98	59	(60)	109,433	73,672	(67)	634,013	453,703	(72)

*Based on 17 implementation survey respondents.

TABLE III-9

RECOMMENDED AND IMPLEMENTED ENERGY CONSERVATION OPPORTUNITIES BY ENERGY TYPE**

Energy Source	Number of ECO's Recom-mended	Number of ECO's Imple-mented	Energy Savings-MMBTU Recom-mended	Energy Savings-MMBTU Imple-mented	%	Dollar Savings Recom-mended	Dollar Savings Imple-mented	%
Electricity	91	62	19,353	10,257	53	272,398	144,640	59
Natural Gas	57	31	73,481	49,967	68	504,040	340,286	75
Fuel Oil	12	6	48,838	48,350	99	49,426	49,426	99.9
LPG	7	4	1,481	1,481	100	8,299	8,299	100
Total (avg.)	167	103	143,153	110,054	(77)	834,163	596,470	(72)

**Extrapolated data from Table III-8 and audit report recommendations to include all audited plants.

IV. CASE STUDIES

During the course of the energy surveys, several plants made serious commitments to an aggressive energy conservation program. Two of the most promising were selected as being of interest to a broad spectrum of manufacturers. Descriptive articles were published in the Appalachian Energy Report. This newsletter was mailed to over 1,200 manufacturers in the Appalachian region of Georgia. Copies of these issues are included in the appendix.

The first company, Universal Ceramics in Adairsville, Georgia, was selected because of the broad applicability of the heat recovery principle upon which their installation is based. This company has cut its natural gas bill by 30 percent since the installation of a second heat exchanger. Installation of the first heat exchanger was documented in the IEES Conserver in 1980. The combined savings due to installations of the two heat exchangers amounted to over 60 percent.

The second plant, a north Georgia textile manufacturer, was selected because of the large savings potential of the conservation measure taken and its applicability to the whole textile industry. This plant converted one zoned textile tenter oven to a counterflow arrangement, resulting in a 56 percent reduction in energy consumption by the unit. Based on the excellent results of the first conversion, a second tenter oven was also modified.

The case studies are an extremely valuable part of the ARC program. These articles highlight the initiatives of industries in the region, adding credibility to the conservation techniques proposed by the Georgia Tech engineers. It is felt that articles such as these are one of the most effective means of convincing industry that conservation measures are both practical and economically feasible.

V. PROGRAM COST/BENEFIT ANALYSIS

Table V-1 on the following page gives specific information on the costs and cost effectiveness of the program. Implementation information on the plants marked by an asterisk has been extrapolated from the actual implementation information obtained on the other 17 plants. The information on the 17 plants was gathered by a telephone survey of the plant contacts. Implementation surveys are continuing, providing actual information with which to complete the table for later updating of this report.

The thirty plants are projected to have invested over $149,000 to implement 78 ECO's, with a corresponding annual cost savings of over $542,000. Excluding the cost of the program -- which was not borne by the client companies -- this results in a savings/investment ratio of 3.63. Alternatively stated, the companies investments will be paid back in just over 3.5 months on the average. First year net savings will amount to $462,867. The plant with the greatest savings/investment ratio (40.2) expects to save $269,860 with an investment of $4,050.

If the program cost of $79,784 is included with the client cost, the savings/investment ratio of the overall program is 2.44. At this rate the total dollar costs will be recovered in about five months. Based on program costs alone, every Appalachian Regional Commission dollar invested in energy conservation in the Georgia ARC region can result in energy savings worth $6.80.

TABLE V-1

PLANT BENEFIT / COST RELATIONSHIPS

Plant Code	No. of ECO's Implemented	Cost of Imple- mented ECO's	Average ECO Impl. Cost	Program Cost	Total Dollar Costs	Annual Dollar Savings	Savings/Cost Ratio
2504/31	3	1,250	417	2,659	3,909	3,817	0.98
2505/32	1	1,876	1,876	2,659	4,535	938	0.21
2214/33	5	4,050	810	2,659	6,709	269,860	40.2
2215/34	7	1,765	252	2,659	4,424	4,448	1.01
2004/35	3	3,200	1,067	2,659	5,859	26,700	4.56
2216/36	0	0	0	2,659	2,659	0	-
2217/37	3	11,596	3,865	2,659	14,255	12,000	0.84
2506/38	2	144	72	2,659	2,803	121	0.04
2218/39	4	6,230	1,558	2,659	8,889	39,370	4.43
3204/40	4	4,313	1,078	2,659	6,972	4,645	0.67
*3004/41	4	430	143	2,659	2,802	18,512	6.61
2005/42	0	0	0	2,659	2,659	0	-
2301/43	3	11,148	3,716	2,659	13,807	8,950	0.65
3902/44	2	23,398	11,699	2,659	26,059	1,016	0.04
2219/45	0	0	0	2,659	2,659	0	-
*3005/46	1	50	50	2,659	2,709	756	0.28
2507/47	1	5,000	5,000	2,659	7,659	2,775	0.36
3006/48	2	2,135	1,068	2,659	4,794	4,000	0.83
*2302/49	2	4,527	2,264	2,659	7,186	4,515	0.63
2303/50	5	4,199	840	2,659	6,858	5,550	0.81
*3601/51	3	7,569	2,523	2,659	10,228	9,500	0.93
*3602/52	2	3,575	1,788	2,659	6,234	4,164	0.67
*2220/53	4	3,544	866	2,659	6,203	16,441	2.65
*2221/54	3	725	242	2,659	3,384	15,743	4.65
*3603/55	2	11,917	5,959	2,659	8,618	9,313	1.08
*2222/56	2	9,649	4,825	2,659	12,308	33,503	2.72
*2006/57	4	20,136	9,534	2,659	22,795	35,322	1.55
*3801/58	0	0	0	2,659	2,659	0	-
*2508/59	2	6,086	3,043	2,659	8,745	6,459	0.74
*3402/60	4	664	166	2,659	3,323	4,233	1.27
Total (Overall Average)	78	149,176	(2,489)	79,784	222,701	542,651	(2.44)

*Implementation Data Estimated On Basis Of Actual Implementation Data From Surveyed Plants.

VI. FUTURE CONSERVATION POTENTIAL

Total energy consumption by end users in Georgia in 1980 amounted to about 1,683 trillion BTU's. Approximately 20.8% of this energy, or 351 trillion BTU's, was consumed in the 35 county area encompassed by the Appalachian Regional Commission. This percentage closely parallels the ratio of the population of the region to that of the whole state, which is approximately 19.6%. Similar comparisons according to end-use sector are depicted graphically in Figure 1.

Annual energy consumption by the industrial sector of the Georgia Appalachian Region amounted to approximately 135 trillion BTU's (in 1980), or roughly 38% of the total energy consumption in the region. Of this amount, the textile industry accounts for 56%, making it the dominant industry group in terms of energy use. The second greatest energy use group, SIC 32 (stone, clay, and glass), consumes only 11% of the region's industrial energy. Figure 2 gives an approximate breakdown of energy use among the major industry groups. The most prevalent energy sources in the region are natural gas and electricity, representing 46% and 31% of total usage, respectively. The approximate distribution of energy use by a source is depicted graphically in Figure 3.

A survey of the industrial population of the region indicates a total of approximately 1,800 industrial plants. Of the major groups, the textile industry is the largest, with 29% of the total population. The remaining groups each represent 10% of the total or less, indicating that other manufacturing in the area is relatively diverse. The textile industry is one of the most energy intensive industries, with a per-plant energy usage almost twice the average.

A total of sixty plants have been audited during the course of the ARC program to date, amounting to about 3.3% of the industrial population of the Georgia ARC region. The thirty plants surveyed under the 1982 program represent only 1.7 percent of the total industrial population. The total energy consumption of the plants surveyed during 1982 amounted to 957 billion BTU's, or about 1 percent of the area's total industrial consumption. If the assumption is made that a similar energy assistance program could reach 50 percent of the region's industrial population, the potential for energy conservation

FIGURE 1 - ENERGY USE PROFILE

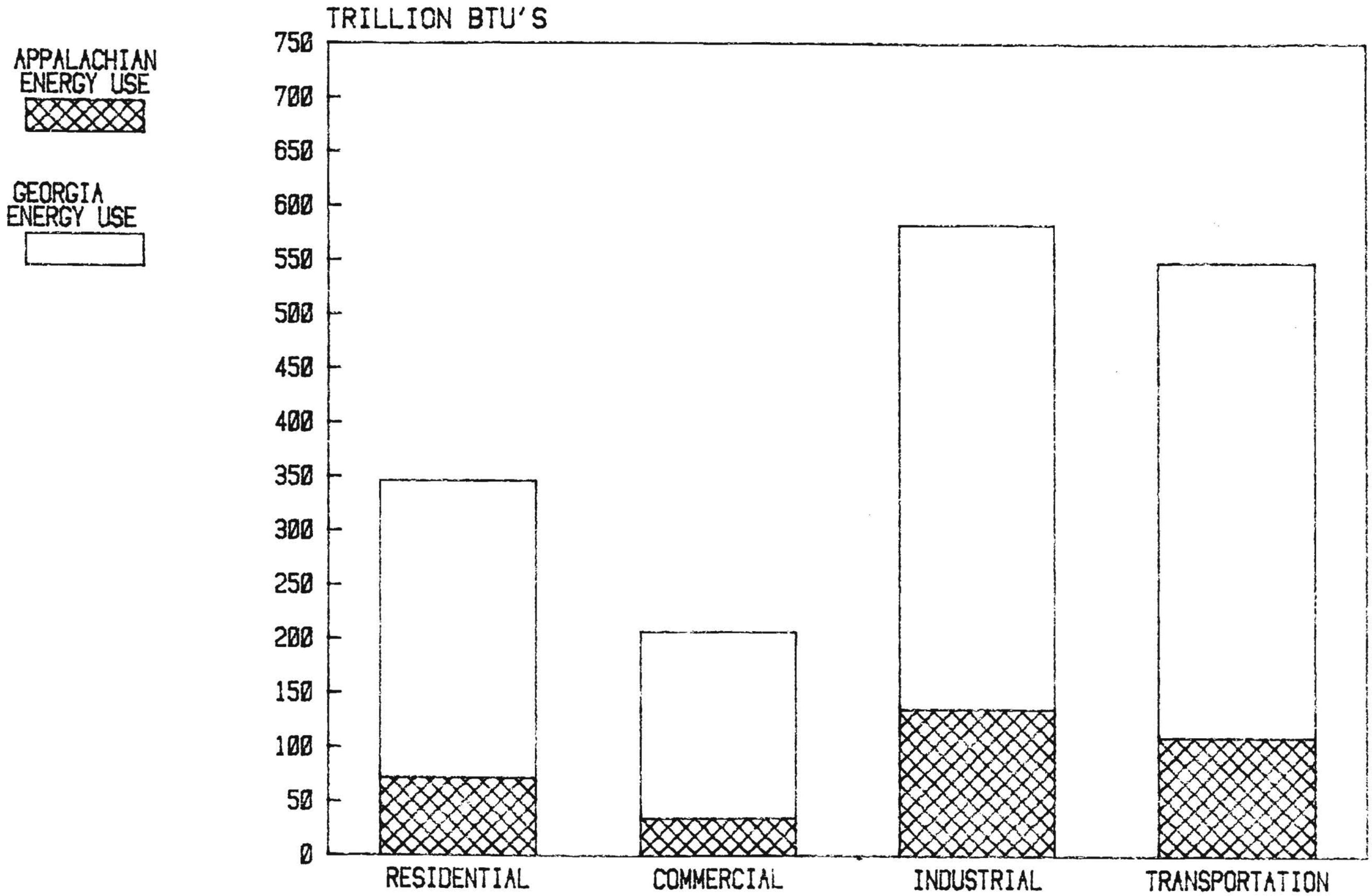


FIGURE 1 - ENERGY USE PROFILE

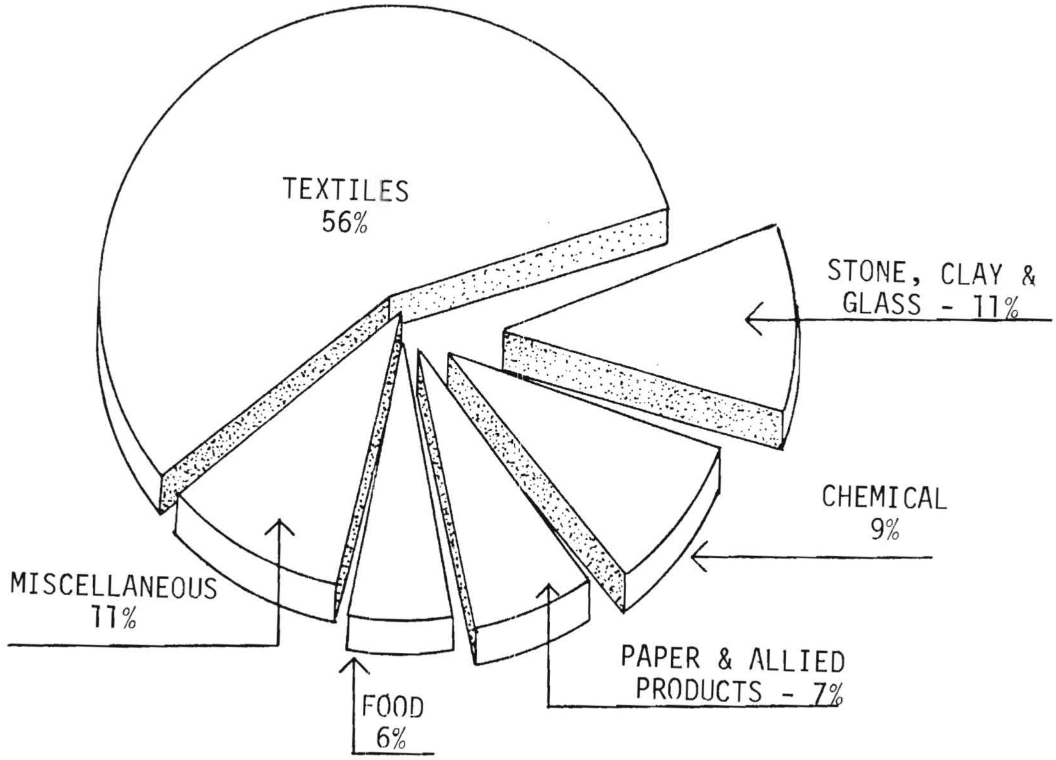


FIGURE VI-2. APPROXIMATE ENERGY CONSUMPTION BY INDUSTRY GROUP

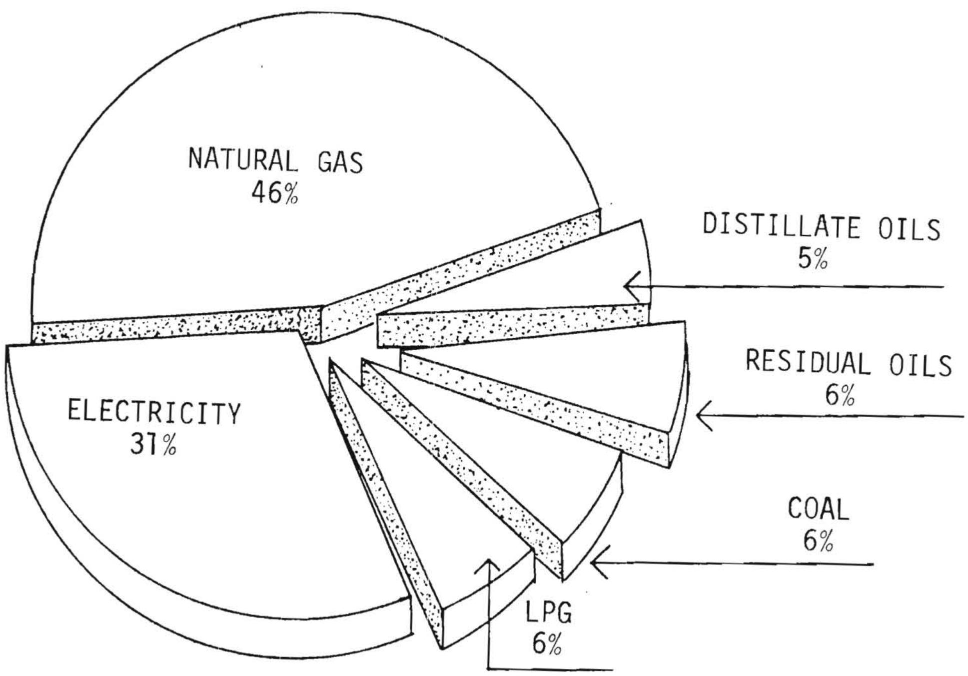


FIGURE VI-3. APPROXIMATE ENERGY CONSUMPTION BY SOURCE TYPE would be 4,200 billion BTU's, or about 3% of the total industrial energy consumption in the region. The corresponding cost savings would amount to over 25 million dollars.

APPENDIX

APPALACHIAN ENERGY REPORT NEWSLETTERS

APPALACHIAN

ENERGY REPORT

Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 1 February 1982

ARC PROGRAM RENEWED

Cost-free energy surveys will again be conducted by Georgia Tech for small manufacturers in the Appalachian region of Georgia, under a program made possible by a grant from the Appalachian Regional Commission to the Georgia Office of Energy Resources. During this funding period, Tech will continue its previous efforts, providing in-plant energy surreys to another thirty companies. Participation in the program is restricted to manufacturers with 200 or less employees. Tech engineers will emphasize energy conservation resources that can be implemented at little or no cost.

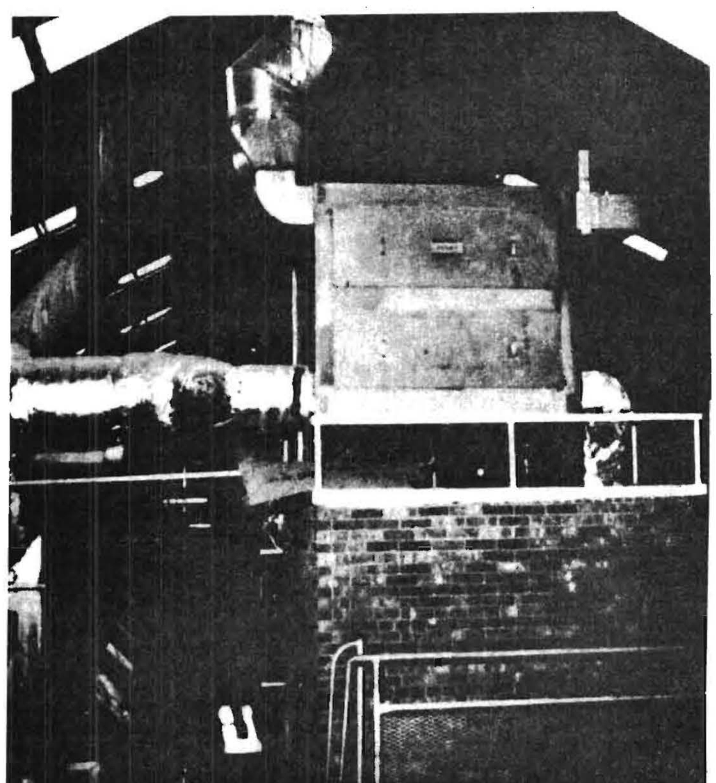
During its first year of operation, the ARC program reached almost 50 companies, and resulted in actual savings of $340,000 annually. Workshops on the fundamentals of industrial energy conservation were conducted in Gainesville and Calhoun. During the current funding period, which extends through September of 1982, a bi-monthly newsletter will be distributed to manufacturers within the region. Each issue of the newsletter will contain a case study outlining the efforts of an area manufacturer toward energy, conservation, as well as energy related news of general interest. If you would like more information on the ARC program, or if your company has an energy conservation success story that might be of interest to others in the region, please contact LuAnn Rockett at EES/TAL, Georgia Tech, Atlanta, Georgia 30332 or call (404) 894-3412.

ARC ENERGY REPORT
LuAnn Rockett, Editor

Published Bimonthly by
the Technology Applications Laboratory

TILE COMPANY INSTALLS SECOND HEAT RECOVERY UNIT

Universal Ceramics, Inc., a quarry tile manufacturer in Adairsville, Georgia, installed a second air-to-air heat recovery heat exchanger in January 1981, after achieving a 32% reduction in their gas bill from the installation of a similar unit in August 1980. Plant management were so pleased with the performance of the first heat exchanger that they decided to incorporate a second unit into the installation of a second tile kiln and dryer. The combined effect of the two heat recovery systems allowed Universal to double their production without doubling natural gas usage.



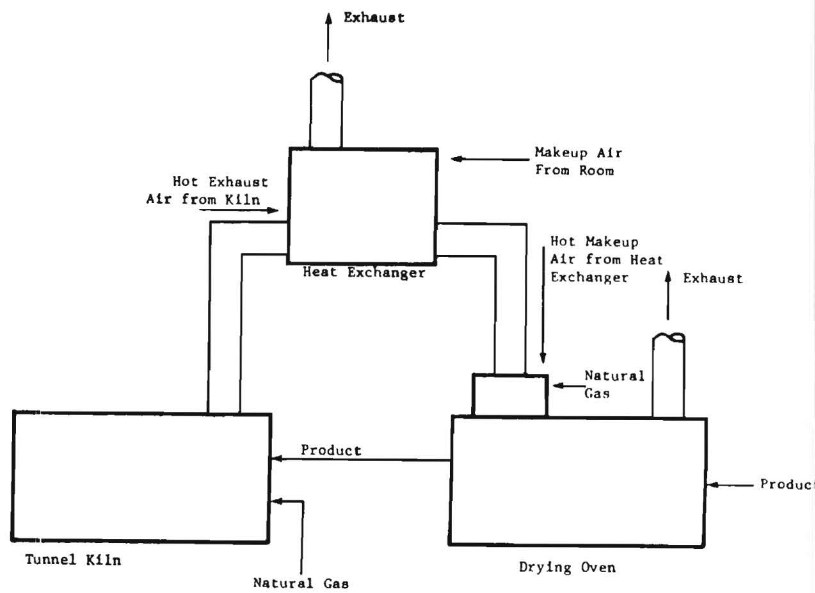
Universal's Heat Recovery Unit

In making quarry tile, shale from a nearby quarry is ground, wetted, and extruded into a continuous strip that is cut into lengths. The rough pieces are dried in a long tunnel type oven at relatively low temperatures (320°F max.), reducing the moisture content from approximately 19% to 0.5%. The dried tiles are then fired in a high temperature tunnel kiln (1800°F) to produce an impervious ceramic product. The drying and firing are both energy intensive processes, using natural gas as the energy source. Prior to installation of the first heat recovery system, Universal consumed over 17 million cubic feet of natural gas each year.

The heat recovery installations at Universal Ceramics use the heat energy in the kiln exhaust gases to preheat the make-up air introduced into the dryer. The air-to-air heat exchanger is a counterflow plate type device that transfers energy from the exhaust air stream to the fresh air stream via the mechanism of conduction through the metal plates. This type unit provides positive separation of the two air streams, preventing moisture and other contaminants present in the kiln exhaust from entering the dryer. The heat recovery systems were engineered by Mr. John English of Resh and Redd Inc., in Atlanta.

The efficiency of the first heat recovery unit installed at Universal was 64%. This figure is typical for a cost-effective industrial application where efficiencies normally range between 60% and 70%. Efficiencies as high as 80% can be obtained with this type of device; however, the additional heat exchange surface area required often raises the cost to prohibitive levels.

The original heat recovery system at Universal was installed at a total cost of $13,000. At that time, savings in natural gas amounted to over $1,900 per month, resulting in a payback of less than seven months. The second system, which utilizes an identical Z-Duct heat exchanger, was installed at a cost of approximately $2000 less than the first, since the heat recovery unit was installed with the new kiln and dryer. The peformance of second unit has been comparable to the first, resulting in an overall plant energy savings of roughly 30%. Plant personnel have reported no loss of efficiency in either unit since their installation.



Heat Recovery Unit Schematic

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Textile Firm Counterflows Oven Exhaust

A north Georgia textile manufacturer recently modified two heatsetting ovens to counterflow the exhaust air. The result was a significant reduction in the amount of air exhausted, and a corresponding reduction in the amount of air taken into the oven that had to be heated to the operating temperature. Gas consumption to the ovens was reduced by over 50%.

The textile operations of drying, curing, and heatsetting are commonly performed in ovens, in which thermal energy is transferred to the textile material by controlled convective heat transfer using air as the heat transfer medium. Most tenter frames and ovens in use today were designed and built when energy costs did not make a significant impact on the cost of a finished textile product, and are consequently not energy efficient. There are several modifications that can be made to existing ovens and tenter frames that will reduce the energy requirements of these thermal processes and do not require a large capital investment. One method that has proved to be effective is the counterflowing of air through the dryer housing.

In a typical textile tenter oven there are several heating zones. Each zone is equipped with a burner or steam coils, and has its own make-up air inlet and exhaust stack. Air is exhausted from the stacks to remove vaporized water and sometimes smoke, particulate matter, or solvents. The amount of hot air exhausted from each zone usually controlled by the speed of the fan installed in the duct, and is normally of a much higher volume than necessary to meet process requirements. The exhausted air usually does not contain as much moisture or other matter as it should before it is exhausted. Thus, the drying or heating capacity of the air is not fully utilized. Since the exhausted air must be replaced by fresh make-up air that must be heated to the oven temperature, exhausting excessive amounts of hot air represents a substantial energy loss. Therefore, a reduction in the exhaust air flow via counterflowing the oven air can result in substantial energy savings.

ARC ENERGY REPORT
LuAnn Rockett, Editor

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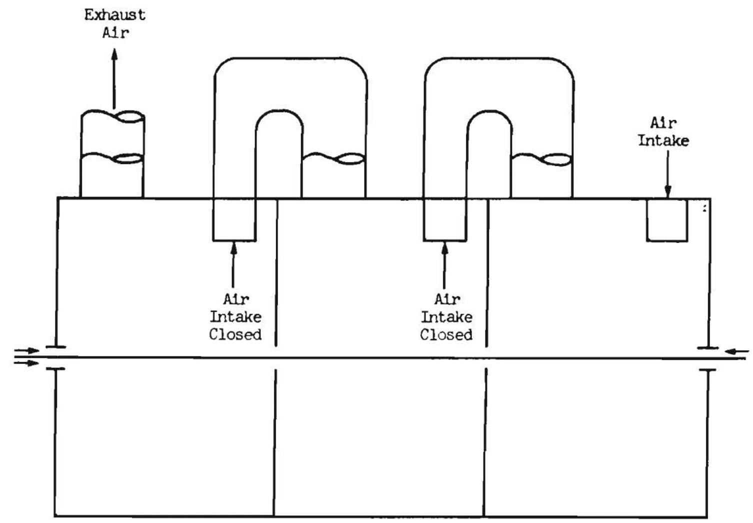
The principle of counterflowing oven exhaust air involves having the cleanest air contact the material that is closest to being finished (this includes drying, curing, and heat setting). Make-up air enters the oven at the product exit end, flows opposite the flow of goods, and is exhausted at the product entrance end. Many new ovens are designed to counterflow as a part of the original operating mechanism. However, for older ovens, some engineering modifications must be made to the exhaust and air intake systems to make the air flow properly. The exhaust stack of each zone can be ducted into the make-up air inlet of the preceding zone, with air taken in only at the last zone and exhausted only at the first zone, as shown in Figure 1. This was the modification made at Plant 22054. Another method would be to simply block off the exhaust stacks for all but the first zone and the make-up air inlets for all but the last zone. This method is simpler, but not as effective as the first method.

The energy consumption for one of the heat setting ovens was measured before and after the counterflow modification was made. The oven typically processed 12 foot wide fabric at an average speed of 80 yards per minute. The measurements revealed that the counterflow modification reduced the energy consumption of the oven by 56%. The results are shown below:

	Energy Consumption
Before Modification	1.968 MMBTU/hr
After Modification	0.867 MMBTU/hr
Energy Savings	1.101 MMBTU/hr

For an average natural gas cost of $3.20 per MMBTU, the annual energy cost savings were $29,595. The capital cost for modifying the oven was $22,865, thus resulting in a pay back period before taxes of 9 months. Based on the excellent results of the first oven conversion, the second oven was also modified.



OVEN WITH COUNTERFLOW MODIFICATION

ARE YOUR ENERGY COSTS OUT OF SIGHT?

If you are interested in reducing your energy costs, complete the form below for a free and confidential energy audit of your plant. Return to:

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Company Name: ______________________

Address: ______________________

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Title: ______________________

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APPALACHIAN
ENERGY REPORT
Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 3 May 1982

FOAM FINISHING SAVES $260,000

Foam finishing is a process whereby the finish is applied to the fabric in an air-blown foam, rather than a pure liquid state. This results in the following advantages over conventional aqueous systems:

- Reduction in energy consumption for drying and curing per pound of fabric,
- More efficient use of chemicals,
- Application to wet fabric without first drying, and
- Reduction in water content of the finish resulting in higher production rates, decreased dryer temperatures and decreased fuel consumption.

To date, foam finishing has gained wider acceptance than foam dyeing, mainly because of the wider latitude in uniformity allowed for colorless finishes than for dyes and pigments. Foam finishing can also result in the elimination of the washing and drying steps after curing, another example of the energy savings possible with foam finishings.

Traditional Operation

An apparel plant has been successfully using foam finishing since 1977. The plant produces fabrics ranging from 1.2 to 4.0 yards per pound. The average fabric weight is 2.5 yards per pound. The fabrics are generally 50% polyester/50% cotton blends, with polycellulosics accounting for 80% of the total production. All fabrics produced in the plant are finished with foam processing.

Until 1977, the plant operated with conventional finishing ranges. The ranges typically ran at 40 to 80 yards per minute, and generally consumed 32 yards per gallon of finishing mix. Drying and curing temperatures ranged from 350° to 375°F when performed in the same step. During this time, total plant gas consumption in the finishing area was 23,100 MMBtu at an average annual cost of $2.61 per MMBtu.

Modifications

In 1977, the conventional finishing ranges were retrofitted with foam systems at an average cost of $25,000 per range. The incentives to invest were two-fold -- projected energy savings and increased production.

The system is shown in Figure 1. Using this type of foam finishing technology, both sides of the fabric are finished at the same time. Production speeds have been increased to 70 to 110 yards per minute using foam finishing, and plant personnel project that with new drying equipment, speeds of over 200 yards per minute can be achieved. Using foam, the wet pick-up has averaged 25% to 35%.

Foam finishing has led to a decrease in chemical usage of 10% to 20%. A typical finish can now be applied at 100 yards per gallon of mix. Energy consumption for finishing has been reduced to 10,100 MMBtu for 1980 at a cost of $5.01 per MMBtu.

ARC ENERGY REPORT
LuAnn Rockett, Editor

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Savings

The initial $25,000 invested in the system was recovered in 25 weeks with $1000 per week in savings due to the decrease in energy consumption. Because the total payback period was so short, the investment was made without any consideration given to return on investment or other economic analyses. Total finishing energy consumption is shown in Table I.

Total savings dollars are based on labor, materials and overhead costs. Energy consumption is also included in this figure. Based on current plant figures, the average savings shown in Table II were compiled.

Table I

TOTAL FINISHING ENERGY CONSUMPTION

	Propane Cost	Energy Usage	Total
Conventional (1977)	$0.249/gal	925 BTU/yd	2.31 x 10^{10}
Foam (1980)	$0.479/gal	405 BTU/yd	1.01 x 10^{10} BTU/
SAVINGS		520 BTU/yd	13,000 MMBtu/yr

Table II

TOTAL FINISHING COST SAVINGS

	Annual	Weekly Average
ENERGY SAVINGS	$ 65,150	$ 1,303
TOTAL SAVINGS	$260,150	$ 5,203

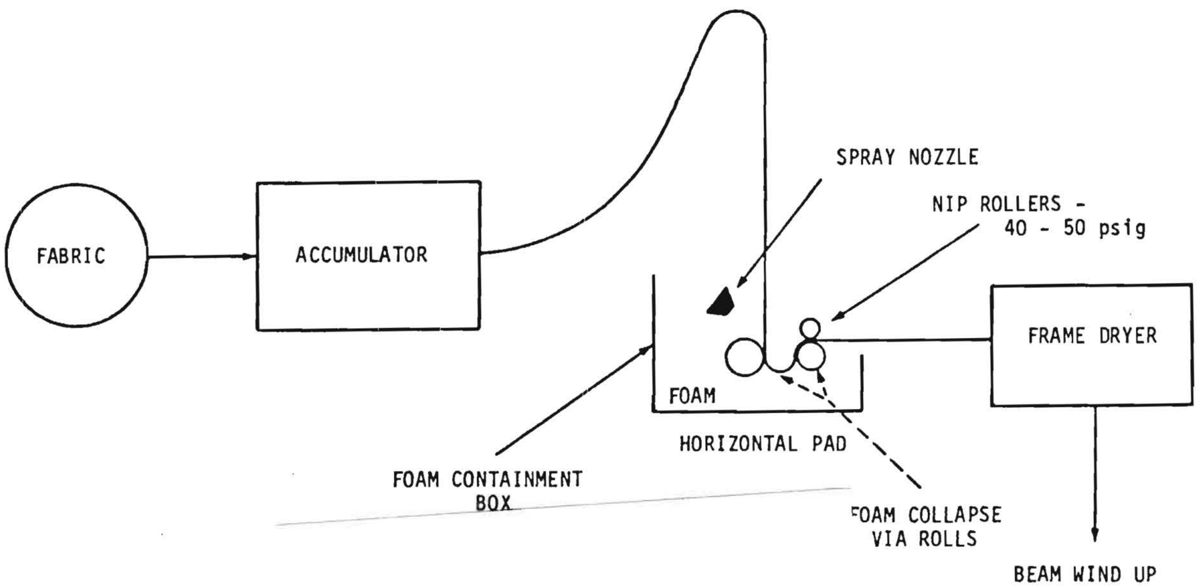

Figure 1 ... System

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ENERGY REPORT
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Improving Boiler Operating Efficiency

One of the more effective means of improving and maintaining boiler operating efficiency is a boiler tune-up. This preventive maintenance item is one of the most direct approaches to fuel conservation through efficiency improvement.

The primary objective in a tune-up is to achieve efficient combustion with a controlled amount of excess air. Operating with the lowest practical excess air will minimize exhaust losses by reducing the quantity of unneeded air that is heated to temperature and then not utilized. The associated reduction in stack gas temperature and power consumption by forced draft and induced draft fans are additional benefits. The actual improvement in boiler efficiency with lower excess air depends on the initial stack temperature and excess air. A given change in excess air will have a greater effect when stack temperatures are high.

Proper operation of the boiler combustion control system is essential for maintaining high boiler operating efficiencies and low excess air levels. Its main purpose is to provide the correct quantities of fuel and air at the burner to satisfy a varying demand for steam generation. Although it is important that the excess air delivered to the burner be kept to a minimum over the boiler operating range, it generally is not practical to operate precisely at the point of maximum efficiency. This optimum typically occurs at the threshold of combustible or smoke formation and may result in unacceptable stack conditions. For most boilers, it is necessary to maintain a margin of excess air above the minimum or threshold level to accommodate variations in fuel properties and ambient conditions, non-repeatability of control settings, normal deterioration of control parts, and rapid changes in firing rate.

To assure reliable, safe, and efficient boiler performance, manufacturers of boiler and burner equipment recommend periodic inspections and tune-ups. Thorough tune-ups are recommended annually, but many operators also prefer to conduct quick boiler efficiency checks much more often, sometimes on a daily or weekly basis (as mentioned in the previous section on performance monitoring). Thus, efficiency problems can be detected before large fuel wastes occur or expensive maintenance is required. Boiler tune-up services are also available from most major manufacturers of boiler and burner systems, some local utilities, and engineering consulting firms. For boiler operators desiring a basis efficiency check of their boiler, the local natural gas supply company may provide this service at little or no charge to customers and

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LuAnn Rockett, Editor

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may also offer some assistance in adjusting burner controls for peak efficiency.

A minimal tune-up should include a verification of automatic fuel and air control operation over their operating range. Visual furnace observations and stack measurements of O_2, CO, CO_2 and temperature are essential elements in this type of tune-up. It is important that excess air not be reduced at the expense of excessive combustibles (unburned fuel, carbon carryover, CO, etc.) since these can represent significant efficiency losses. More than 400 ppm carbon monoxide (CO) in the stack gases in generally not acceptable.

Water Quality Control and Blowdown

Water treatment is an important aspect of boiler operation that can affect efficiency or result in plant damage if neglected. Boiler feedwater contains impurities in solution and suspension. These impurities concentrate in the boiler water since the steam generated is essentially pure. If these suspended solids are allowed to concentrate beyond certain limits, a deposit or scale will form on the boiler heating surfaces which will retard heat transfer and increase tube metal temperatures. This can lead to increased stack gas temperatures that reduce boiler efficiencies. Even more important is the probability of furnace tube failures from overheating as a result of the insulating effect of water-side scale.

Chemical treatment of the boiler water is necessary to counteract the adverse effects due to concentration of impurities introduced with the makeup water. Blowdown is required to reduce the build-up of impurities and expended chemcials. Thus, the amount of blowdown required is dependent on the type and operation of equipment, impurities in the make-up water, and the make-up water addition rate.

Other areas that should be considered with a boiler maintenance program are:

- Combustion efficiency spot checks
- External tube cleanliness
- Boiler insulation
- Flue gas heat recovery
- Load balancing
- Reduced boiler steam pressures
- Condensate return
- Steam leaks
- Steam traps

For more information on these specific topics, contact the ARC program at (404) 894-3412.

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APPALACHIAN

ENERGY REPORT

Produced by the Georgia Tech Engineering Experiment Station for the Appalachian Regional Commission

Vol. 1, No. 6 November 1982

Evaporative Roof Cooling Systems

When a roof gets hot in the summer, why not cool it off by spraying it with water? This simple and straightforward approach to summer cooling has been around for a long time, yet it is not in wide use. Part of the reason seems to be the widespread misconception that a roof spray system will shorten the life of a roof by subjecting it to more frequent thermal cycling than normal. The thermal cycling is thought to cause the roof to contract and expand until it cracks and begins to leak.

In actuality, a properly designed and installed roof spray system, or evaporative roof cooling system (ERCS), can lengthen roof life, cut air conditioning costs, and increase plant comfort level.

HOW AN ERCS WORKS

An industrial roof spray system consists of three parts: spray piping on the roof, a pump, and a sensing and control circuit. The spray piping may be metal, such as copper, or plastic, such as poly vinyl choloride (PVC). The piping has holes drilled through the wall of the pipe at regular intervals along its length. Water pumped through the piping sprays through these holes, or nozzles. The pump is operated by a control circuit which senses the roof temperature and turns on the roof spray when the roof temperature reaches 90°F. The spraying generally proceeds sequentially in zones, each zone being sprayed for about 20 seconds. After all the zones are sprayed the roof temperature is again monitored. If the roof is still too hot after it has been sprayed, intermittent spraying continues until the roof is below the 90°F setpoint.

Only a very small amount of water is sprayed on the roof. The amount sprayed is regulated so that all the water sprayed during one cycle evaporates from the roof before that area of the roof is sprayed again. The water does not pond or puddle. Puddling reduces evaporation and markedly reduces the cooling effect of the water. Each pint of evaporated water absorbs about 1070 Btu's of heat from the roof.

MAJOR BENEFITS

Reduced Air Conditioning Costs

Cooling the roof of a plant with an ERCS can reduce the amount of solar heat gain through the roof by as much as 70%. Less heat input to the plant requires less air conditioning to remove it, bringing about energy and cost savings due to reduced electrical consumption. In addition to reduced consumption, there may be a reduction in electrical demand. Most industrial electricity consumers pay all year for the peak demand they set during a half hour period sometime in the summer. By reducing the electrical demand in the summer, the billing demand can be substantially reduced over the rest of the year. Dollar savings due to a reduced demand can easily outweigh savings in reduced consumption.

Increase in Comfort Level

An asphalt roof on a plant may reach 150°F during a clear and bright summer day. Much of this heat is conducted through to the ceiling, which may reach a temperature of 120°F. Even though the air temperature in the plant may be at a comfortable level,

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working under the hot ceiling can be quite uncomfortable, resulting in an "in the oven" feeling. A spray cooled roof, however, can reduce these high temperatures, eliminating the oppressive hot ceiling feeling.

Increase in Roof Life

An ERCS can actually prevent destructive thermal cycling in the roof, and can increase roof life by 100%. An uncooled roof suffers from the high temperatures it can reach on a clear summer day. The heat causes the asphalt and bituminous roofing materials to soften, expand, blister, and creep. Volatile oils which keep the roof pliable are driven off, resulting in a hard and brittle roof. Sudden cooling of the hot roof by summer rain showers causes intense thermal shock, making the roof crack and pull apart.

A roof cooled by an ERCS never gets very hot. The roof materials retain their volatile oils and their pliability, and are not subject to severe thermal shocks from summer rain showers.

COSTS AND SAVINGS

The installed cost of an ERCS will vary according to the type of roof and its area. Typical installed costs vary from about 30¢/ft^2 for a small roof to 18¢/ft^2 for a large roof. One vendor recently quoted an installed cost of $9200 for a 40,000 ft^2 roof.

Annual operating costs for an ERCS consist of minimal electrical power costs for the pump and control system, and the cost of water. Water costs vary according to local rates, but for a rate of 40¢ per 1000 gallons the annual water cost is about $5.00 per 1000 ft^2 of roof. Water costs can be reduced or eliminated by using clean waste water equipment used for cooling. In this case a holding tank and a transfer pump would be required in addition to the standard system.

PAYBACK

One plant recently examined by the Experiment Station showed a 2 year payback on the installation and operating costs of a roof spray system. The payback period for other plants would vary, depending on the electricity and water cost, amount of air conditioning, and roof area.

A NOTE OF CAUTION

Let the buyer beware! While the foregoing information is accurate for a properly designed, installed, and maintained ERCS, an improperly designed or installed system may yield poor results or even cause roof damage. Before making a purchase commitment to any particular manufacturer, get a list of customers who have had the systems installed. Call or visit them to find out what their experience has been.

This newsletter should not be construed as an endorsement of any particular manufacturer or product.

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